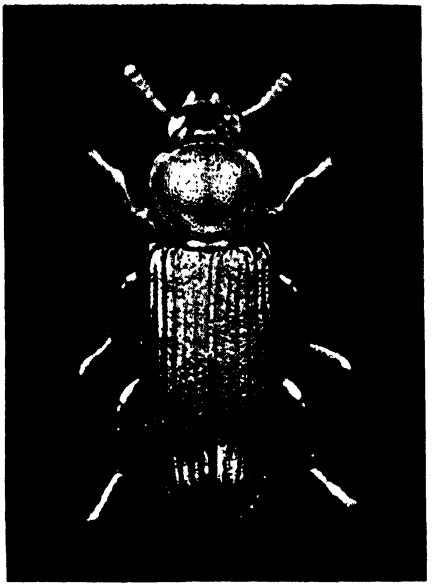

Tribolium destructor Uytt.
Above, adult. × 10;
below, larva. × 5.

[*Frontispiece.*

INSECT PESTS
IN STORED PRODUCTS

By
H. HAYHURST, F.I.C., A.M.I.CHEM.E.

Photographs by
HARRY BRITTEN, F.R.E.S.

WITH A FOREWORD BY
SIR HAROLD HARTLEY, C.B.E., F.R.S.
Vice-President, London Midland and Scottish Railway Co.

AND A PREFACE BY
T. W. JONES, B.Sc.
Editor, *Industrial Chemist* and *Food*

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FOREWORD

By SIR HAROLD HARTLEY, C.B.E., F.R.S.
Vice-President, London Midland & Scottish Railway Company

THE problem of preserving foodstuffs from avoidable waste or deterioration is second only in importance to that of their production and distribution. Much of this loss can occur through the attack of insects, and this form of infestation is one that the railway companies, as large owners of warehouses, have to be on guard against constantly. The railway chemist is called upon to identify the type of infestation and to recommend precautionary or remedial measures, and in this capacity Mr. Hayhurst has had unusual facilities for becoming an expert on a problem which has not hitherto received wide treatment, though it is now the subject of attention by a Committee recently set up by the Department of Scientific and Industrial Research.

As a result of widespread and systematic observation, Mr. Hayhurst has not only been able to catalogue the wide variety of insects which have come to his notice, but also to provide detailed information on the habits of the different species, together with extremely valuable lists of the products which each variety has been found to attack. The text is greatly enhanced by an excellent series of photographs

specially taken by Mr. Harry Britten. Though compiled from information gained in railway warehouses, the book should make a direct appeal to all commercial undertakings which require to store products liable to insect infestation.

H. HARTLEY.

EUSTON STATION.
June 15th, 1940.

PREFACE

By T. W. JONES, B.Sc.
Editor, *Industrial Chemist* and *Food*

As Mr. Hayhurst points out in his opening paragraphs, it is impossible to assess with any accuracy the annual loss to this country caused by insect infestation of stored products, but it must obviously amount to many millions of pounds sterling. In wartime that loss must be prevented to the very utmost of our ability, and particularly when foodstuffs are involved. It is, therefore, not surprising that the Government should in June, 1940, have accepted the offer of the governing body of the Imperial College of Science and Technology to place at the disposal of the Department of Scientific and Industrial Research, for the period of the war, all the accommodation of the Biological Field Station at Slough that may be required for the purposes of the Department's work on insect infestation of produce. It will be recalled that in June, 1938, the Pest Infestation Research Committee was set up under the chairmanship of Professor D. M. S. Watson, F.R.S., and that the Department used parts of the laboratory at Slough in 1939. In June, 1940, the Department took into its own employment the staff of the Imperial College hitherto engaged in this field work, and secured the services of Professor J. W. Munro as consultant.

That Research Committee has already issued three useful publications: a leaflet of common pests of grain and other stored products, a wall chart, and a pamphlet entitled *The Principles of Fumigation of Insect Pests in Stored Produce.* When mentioning work carried out in this country, sight must not be lost of that undertaken by the British Association of Research for the Cocoa, Chocolate, Sugar, Confectionery and Jam Trades, who put forward two handy booklets at the end of 1938. The British Museum has a special Economic section of its Entomological Department that deals with questions relating to insect pests.

With the exception of the above publications, information upon the prevention and cure of insect damage has been exceedingly difficult to come by. Even more serious has been the complete lack of a practically useful description of the harmful pests. It is not realized that of the millions of insects that exist, comparatively few are destructive of stored products, or that a few others are even beneficial in that they prey upon the destructive ones. In this book by Mr. Hayhurst and Mr. Britten, these insects are classified and described with adequate illustration. The practical experience over many years that these authors possess is sufficient recommendation for the authority of the book; I feel that it will supply information obtainable nowhere else, and that it amplifies and assists the few publications referred to above.

The genesis of this book is worth telling. In the course of my work I was struck by the number of

inquirers who wrote to me on *Food* asking questions about insect damage to foodstuffs. Except for Professor J. W. Munro, to whom I referred more than one of them, there was no source of help: the literature was scanty and scattered. The situation was like meat to a hungry man. For a year or two I hunted for somebody with large-scale practical experience to write the obviously missing series of articles for *Food*. In December, 1937, there came on my desk a reprint of a paper by Mr. Hayhurst illustrated by photographs by Mr. Britten. The photographs were just what I wanted, but the text needed filling out with practical day-to-day data. In Mr. Hayhurst I found a most willing and resourceful collaborator, and he and Mr. Britten immediately started work upon the series. It was not however until two and a half years later that we were ready to publish, and the first article with its illustrations appeared in August, 1939. In spite of wartime difficulties in technical journal publication the remaining articles appeared regularly. Their successful filling of a gap in technical literature was immediately obvious: many congratulatory letters came in, the number of inquiries for information dropped, and were succeeded by requests for the series in book form. The articles appeared under the general title of "Insect Infestation of Stored Products," one we felt a little unwieldy for a book. In addition, it was suggested by Mr. John L. Bale, Technical Managing Director of Messrs. Chapman & Hall Ltd., that we should include a handy reference tabulation of pests known to have been found in individual commodities.

Further, there are a few minor additions to the text. As will be seen, the text follows a general plan whereby the orders are first referred to, after which follow the families containing insects of interest, and then the pertinent insects are described and their recorded habitats enumerated. Wherever it has been possible to obtain a specimen there will be found photographs of the larvæ and adult insects taken by Mr. Britten. The endeavour throughout has been to provide practically useful information to those engaged in the transport, the manufacture, the wholesaling and storage of perishable goods, and particularly, of course, foodstuffs. The text, whilst technical, is not bewilderingly so, and Mr. Hayhurst has deliberately written it in such a way that any technical man without much entomological knowledge can readily understand and follow it.

Acknowledgment is made with considerable gratitude to the Nema Press for permission to reproduce much of the text and illustrations.

T. W. JONES.

CONTENTS

The reader should note that the magnifications of the photographs vary. Indication is given against each illustration.

INSECT PESTS IN STORED PRODUCTS

THE problem of the infestation of stored products does not appear to have received sufficient attention in the past, possibly because there is a mistaken belief that infestation cannot be avoided. From time to time, estimates have been published of the loss due to insect infestation, but many of these estimates have been confined to one particular commodity or group of commodities, so that the whole problem has never been completely surveyed. It is impossible to estimate with any degree of accuracy the loss caused by insects in this country to stored products. It is, nevertheless, a very heavy one.

In this connection, there are two aspects which must be considered in assessing loss from this cause :

1. Actual depreciation. Foodstuffs intended for use for human consumption may have to be used for animal feeding or the preparation of animal foods, or even destroyed. Claims may arise because goods are infested, or the market value fall because of the condition of the goods.

2. Loss of goodwill or prestige, and of business, may result when infested goods are supplied, even where it can be shown that it is impossible for a particular commodity to be damaged by the pest which is present, but that it has inadvertently gained access to the goods during transport or storage.

There is a popular belief that the insects originate

from the material itself; this is incorrect. The chief insects which we encounter in stored products are moths and beetles, both of which pass through a similar life cycle, *viz.*, egg, larva, pupa, and adult insect (moth or beetle). Bearing this life cycle in mind, it is obvious that the commodity cannot "generate" insects. There are, of course, a number of ways in which infestation can arise, for example, in the field (in foreign-grown but not in English-grown grain), in store, during transport; or infestation may be due to the use of sacks which have previously contained infested material.

A large number of the insects now found in stored products in this country propagate within the material from generation to generation whilst in store. Many of these insects have been introduced into this country in commerce, and, although not originally British species, they are now so widespread as to be included in the lists of these.

The chief insects found on stored products are those which feed upon or damage the material; there are others which do no damage and do not feed upon the material, but are predacious upon insects already present. These predatory insects exert a controlling influence, though their numbers are usually so small as to be incapable of keeping the other insects in check.

Much can be done to prevent or control infestation by simple measures, of which the most important is the cleanliness of the store. It is a fact that those warehouses which are systematically cleaned give the least trouble with infestation. The lengthy storage

of products aids infestation, because it permits the life cycle of the insects without interruption for a few generations. Where there is a general stock of one commodity, deliveries should be made in order of age.

Mites often infest stored products, and although they are not insects, they are sufficiently closely related to be dealt with along with insects in this survey.

Before passing on to the consideration of the insects which are found in or on stored products, it is necessary to define an insect, and to consider the main groups into which insects are classified.

The body of an insect is divided into three parts, the head, thorax and abdomen. The head carries a pair of antennæ (feelers). The thorax carries three pairs of legs on the underside, and above are the wings—when present—usually one or two pairs. On the abdomen there are no legs or similar appendages. Any creature when adult with more than three pairs of legs is not an insect. In the orders or groups in which they are classified, insects vary widely in shape, size, colouring and habits, but in the sub-groups or families the relationship is much closer, except with regard to size and colour.

Insects from the following orders are found in or on stored products :

Coleoptera	.	Beetles.
Lepidoptera	.	Moths and butterflies.
Diptera .	.	Two-winged flies.
Hemiptera	.	Bugs or sucking insects.

Hymenoptera	.	Ants, bees, wasps, ichneumon flies, etc.
Orthoptera	.	Cockroaches, grasshoppers and stick insects.
Psocoptera	.	Book lice (some winged, others wingless).
Thysanura	.	Bristle tails (always wingless).
Siphonaptera	.	Fleas

In some respects it is unfortunate that many insects have no common English names ; where these are known and in general use, they will be given after the scientific name.

The term " weevil " is often misapplied to include many or all insects which attack cereals and cereal products. Actually it should only be applied to a relatively small but important family of beetles.

COLEOPTERA

About 190,000 species of Coleoptera have been described, of which 3,500 inhabit the British Isles. They vary enormously in size, ranging from 155 to 0·5 mm. The Coleoptera are the most numerous species found in stored products, and they cause damage in the adult and larval stages.

Curculionidæ

In this family are included the weevils which cause the greatest damage to cereals.

Calandra granaria is known as the granary or grain weevil. It is cosmopolitan in distribution. It is not a native of this country, but has been introduced

through commerce and now propagates in warehouses and stores. In some countries the insect attacks the grain growing in the field, so that the crop is infested when harvested, and in consequence serious damage results if stored for any length of time without treatment.

This insect is dark brown to black in colour, and about 2–3½ mm. in length. Like all the weevils, it has a pronounced snout which it uses for boring into grain or seeds. The eggs are laid inside grains of wheat, etc. The female, after boring a cavity with her proboscis, inserts an egg, and seals the cavity with quick-drying fluid of a gelatinous nature, discharged before the ovipositor is withdrawn. When hatched, the larvæ feed on the starchy material inside until they are fully fed. The larvæ usually pupate inside the grains, and only emerge as fully developed insects. The life cycle from egg to mature insect varies with the temperature; in this country the average time may be regarded as about 5 weeks. There may be 3–4 generations in a year. Often grains of wheat and other cereals are so seriously affected by this insect and the larvæ that only the husk of the cereal remains. The average length of life of the mature weevil is 7 to 8 months, and they deposit from 60 to 250 eggs during that period.

This insect has been recorded on all cereals, bran, thirds, seconds, flour, meals, straw, wool, wheat and barley screenings, wheat dust, prepared poultry and cattle foods, malt culms, currants, figs, macaroni, and semolina.

Calandra oryzæ is commonly called the rice weevil.

It is cosmopolitan in distribution, and like the grain weevil it attacks all cereals. In size and colouring it resembles *Calandra granaria*, but is distinguished from it by four orange-red patches on the elytra (anterior leathery or chitinous fore-wings which form a protection to the hind-wings. In some insects which have no power of flight, the elytra are united). It propagates in warehouses and stores in this country, and it is known to attack cereals, etc., growing in the fields in some countries. Its habits and development are similar to *Calandra granaria*, the life cycle in this country being about 6 to 8 weeks. It has been recorded on the following products : all cereals, meals, wool, cotton waste, prepared cattle and poultry food, straw, sugar beet pulp, soya beans, flour, dried peas and beans.

Sitona hispidulus is also cosmopolitan in distribution, but it is rarely met with in large numbers. It is about 3–4 mm. long, and black in colour, clothed with fuscous brown scales variegated with small black patches and stiff outstanding setæ (pointed bristles or long stiff hairs rising from the epidermis or outer skin of the insect). It has been recorded on oats, leguminous products, clover, etc., but is principally destructive to the growing crops.

Ptinidæ

A number of members of this family infest stored products, and they are often troublesome in warehouses because of their wandering habits. They often pupate in the crevices between the floorboards, and, because of this, successive stocks become infested.

The insects are characterized by their globular shape and long antennæ. The larvæ are fleshy, crescent shaped, and white in colour.

Ptinus fur is cosmopolitan in distribution, but it appears to be less frequently found in this country than formerly. It is brown in colour, and approximately 2–4 mm. long. The larvæ are fleshy white grubs, with the body bent in a semicircular position. There are no ocelli (ocelli are simple eyes which have a single facet to each ocellus, as distinct from compound eyes with a number of facets), and the antennæ are short and inserted directly above the mandibles ; the latter are brown, the only colour noticeable in the larvæ. The sexes are dimorphic, the male with very long antennæ and oblong parallel-sided body, the elytra with well-marked shoulders and strong rows of punctures (depressions or small pits in the elytra, like those made by a needle) ; interstices are narrow. The legs are long and slender, with apex of femora elongate-clavate. The female has the antennæ much shorter, and is ovate, subglobose in shape, with finer punctures and much broader interstices ; legs shorter and stouter, with apex of femora scarcely clavate. It has been recorded on oats, barley, straw, old wood, birds' nests, decaying animal and vegetable refuse, ginger, cacao, dates, in houses and granaries, and on warehouse walls.

Ptinus subpilosus is rarely found, and does not appear to be widely distributed in this country. It is brown in colour, and approximately 2–2½ mm. long. The sexes are dimorphic, but not so noticeable as in *Ptinus fur L.* It lacks the white tufts of hair

which are so noticeable in the other species. It has much longer setæ and coarser punctuation of the elytra. It has been recorded in rotting wood, under bark, and on warehouse walls.

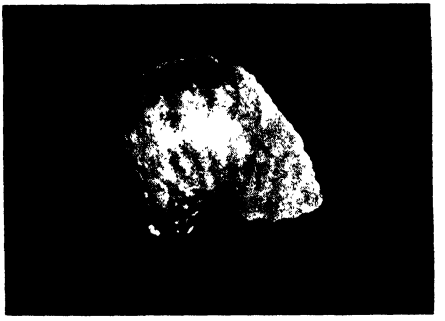
Ptinus tectus is cosmopolitan in distribution, and is now found in all parts of this country. Up to about 1912 it was rarely found in this country. It was introduced as a British species in 1904. It is assumed to be a native of Tasmania. It is brown in colour, and about 2½–3 mm. long. Larvæ are similar to those of *Ptinus fur*. The sexes in this species are similar in shape and sculpture.

It has been recorded on wheat, barley, rice, dari, oats, hops, barley meal, rice meal, sweepings, bran, flour, cotton seed meal, sugar, thirds, wheat screenings, peas, cattle-feeding cake and nuts, maize, flat corn meal, sharps, empty sacks, grass nuts, broad bran, rolled oats. Plate maize, oatmeal, chaff, wheat meal, maize meal, crushed oats, chop, seconds, flaked maize, cut maize, cornmeal, horse corn, cattle meal, malt culms, cattle-feeding nuggets, linseed cake, clipped oats, grass meal, middlings, pinhead oatmeal, laying meal, cut wheat, grower's mash, poultry corn, cattle food, balanced ration, layer's scratch feed, Sussex ground oats, poultry biscuit meal, straw, Maple peas, shudes, ground nut flakes, farina, sago flour, fine maize, poultry food, soya meal, locust meal, hen wheat, fattening meal, dairy nuggets, dairy meal, sweetened palm meal, bean pickings, layers' mash, laying summer meal, chick-raising grain, fattening nuts, dairy nuts, lamb nuts, chick baby food, laying winter meal, calf meal, calf nuts,

(Note : Magnifications vary. Indication is given against each illustration.)

FIG. 1.—*Calandra granaria* L. × 6.

FIGS. 2 AND 3.—Adult of *Calandra oryzæ* L. × 6 ; and larva × 13.



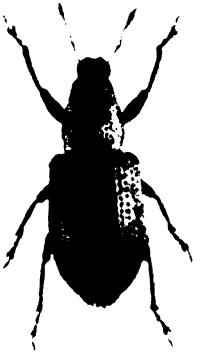


FIG. 4. *Sitona hispidulus* F. × 6.

[*To face page* 8.

Ptinus fur L., FIG. 5, left, male ; FIG. 6, right, female. × 6.

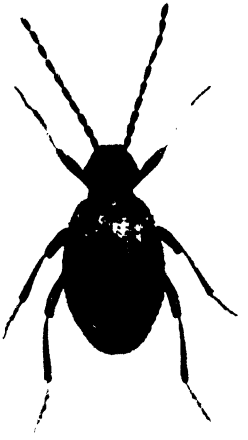


FIG. 7.—*Ptinus subpilosus Sturm.* female. × 6.

Ptinus tectus Boeild :
FIG. 8, left, adult. × 6.
FIG. 9, above, larva. × 13.

FIG. 11. *Niptus unicolor Piller.* × 6.

FIG. 10.—*Niptus hololeucus Fald.* × 6.

PLATE 4

FIG. 12. *Trigonogenius globulus Sol.* × 6.

FIG. 13.—*Mezium affine Boeild.* × 6.

FIG. 14.—*Gibbium psylloides Czp.* × 6.

To face page 9.]

pig rearing nuts, pig meal, white rolled oats, B. & W. rolled oats, split maize, calf cobettes, chick feed, dairy milk meal, bean meal, laying pellets, linseed bean meal, balanced dairy nuggets, pig foods "A" and "B," nutted linseed cake, earth nut flakes, milk nuts, rye flour, hop grass nuts, cacao, nutmegs, almonds, ginger, figs, sultanas, dried pears, dried apricots, Chili pods, cayenne pepper, goat-skins, reclaimed rubber, fox-skins, in the feet of prepared furs, bird and museum prepared specimens, and on warehouse walls and floors.

Larvæ are recorded on cattle-feeding cake, meal and nuts, wheat screenings, rice meal, sweepings, warehouse floors, rolled oats, cattle food, pig meal, balanced ration, thirds, chick baby food, dried peas, dried apricots, sultanas, and cacao.

The pest propagated for 11 years in a tin of a famous firm's cocoa, and was still flourishing on the remainder of the cocoa in the bottom half of the tin, the upper half being filled with dead bodies of the beetles and their cocoons. It was still breeding after 10 years in a sample of cayenne pepper. A sample of bleached almonds was simply "ground" by the beetles and their larvæ, and the colony is still thriving after 18 years in the remainder of these nuts in a closely sealed glass jar. Larvæ were found feeding in reclaimed rubber, and remained feeding for several years, generation after generation.

Niptus hololeucus is frequently termed the golden spider beetle; in Lancashire an alternative name is the cloth bug. It is an important pest, appears omnivorous in its habits, and is cosmopolitan in

distribution. It is golden in colour, and about 3–4 mm. long. Larva is a rather larger grub, very similar to that of *Ptinus fur*. It has been recorded on the following: wheat, meal, dog biscuits, rice meal, flour, oats, rice, cattle-feeding cake and nuts, malt culms, Plate maize, chop, crushed oats, barley meal, scratch feed, shudes, empty sacks, Sussex ground oats, sago flour, soapstone, maize meal, farina, bran, thirds, maize, bean pickings, wheat meal, laying meal, linseed bean meal, Plate wheat, Barusso wheat, crushed oats, cement, laying mash, corn meal, goat skins, feet of prepared furs, in cacao and spice warehouses, European granaries, old houses, in bird and animal museum specimens, warehouse walls and floors.

Niptus unicolor is a smaller, strongly crenate-striate species, of a dark brown colour, much less common than its golden relative, but equally widely distributed, though its depredations are more obscure. Apart from its occurrences in houses, stores, warehouses and bakehouses, there is no direct evidence of any damage being done. It is approximately 2–3 mm. long; larvæ are not known.

Trigonogenius globulus is known as the ptinid beetle, and is widely distributed. It is about $2\frac{1}{2}$–$3\frac{1}{2}$ mm. long, and greyish brown in colour. It has been found on rice meal, wheat, meal, rice, seconds, flour, sugar, bran, thirds, broad bran, Sussex ground oats, rye flour, poultry food, sweepings, dried pears, vegetable ivory, argol, in flour mills and on warehouse walls and floors. It is abundant in cotton mills, feeding on food refuse where the mill workers

had their meals, and evidently using the cotton seeds as its chief pabulum ; the clearing out of these sources of food supplies completely stopped the complaint about this beetle.

Mezium affine does not appear to be as widely distributed as formerly, and appears to be restricted to Europe. It is reddish brown in colour, with head, thorax as well as legs and antennæ, clothed with thick yellowish pubescence, sharply contrasting with its smooth and shining elytra, which looks like a shining brown bead, it being so strongly inflated and globose. It is about 2–3 mm. long, and has been recorded on flour, warehouse sweepings, debris of haystacks, dry vegetable refuse, in cotton mills and in houses.

Gibbium psylloides is also European, and is not frequently found associated with stored products. It is about 2–3 mm. long and reddish brown in colour, strongly globose like *Mezium affine*, but lacking the thick yellowish pubescence of the head end of that species. It has been recorded on flour, debris of haystacks, warehouse sweepings, dry vegetable refuse, and in bakeries ; also abundant on occasions in cotton mills, feeding on the debris of cotton seeds and scattered food particles from the workers' food.

Dermestidæ

Most members of the Dermestidae family infest skins, hides, wool, etc. ; the larvæ are very destructive, and mainly responsible for the damage. Most of the mature insects in this group are covered by fine hairs or scales. The larvæ of this family can be

distinguished from the larvæ of all other coleoptera by the hairy coating and tufts of hair. The members of this family are dangerous in warehouses, etc., because of their ease of migration. They are known to travel relatively long distances by walking, and they are capable of flights of short duration.

The species of *Dermestes* are frequently reported as doing damage amongst goods of various kinds, when the presence of the beetle or its larvæ is purely adventitious, the commodities having been in close contact with infested hides or other products during transit or storage. The beetles and larvæ have crawled into the various goods to hide, or, with larvæ when fully grown, as a convenient place wherein to pupate, so that reports of damage to cotton goods or even manufactured woollen goods should be closely scrutinized before accepting the report of damage. This also applies to various reports on infestations of cereals, etc.

Dermestes vulpinus is widely distributed, and is frequently found on hides and skins. It is about 6–9 mm. long, and black in colour, with white markings on the underside. The larva is brown, covered by tufts of hair, and about 12–14 mm. long. *Dermestes vulpinus* has been recorded on wool, lambskin, carpets, cacao, cowries, tobacco, furs, dried fish, and hides, and the larvæ on lambskin, wool and carpets.

Dermestes frischi is not very common, and is mainly found in Europe, Asia and North America. It is brownish black in colour, with white patches on the underside, and is about 6–8½ mm. long. It has

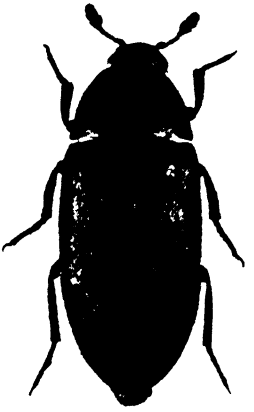


FIG. 15.—*Dermestes vulpinus F.* adult. × 6.

FIG. 16.—*Dermestes vulpinus F.* larva. × 4.

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PLATE 6

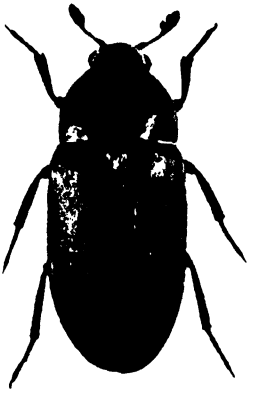


FIG. 17.—*Dermestes frischi Kug.* × 6.

FIG. 18.—left, *Trogoderma granarium Ev.* adult. × 3.
FIG. 19.—right, same, larva. × 6.

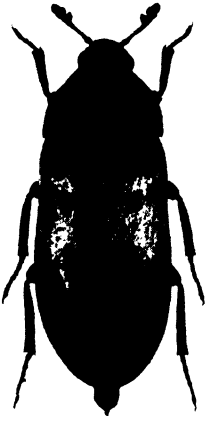


FIG. 20.—*Dermestes lardarius L.* adult. × 5.

FIG. 21.—*Dermestes lardarius L.* larva. × 5.

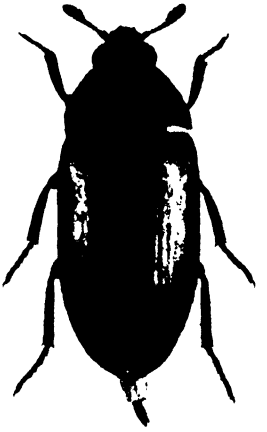


FIG. 22. *Dermestes oblongus Sol.* adult. × 5.

FIG. 23.—*Dermestes oblongus Sol.* larva. × 5.

To face page 13.]

been found on wool, dog biscuits, carrion, cowries, dried fish, and cacao, and in spice warehouses; the larvæ of this variety have been found on dog biscuits.

Dermestes lardarius is known as the larder beetle and as the bacon beetle; it is cosmopolitan in distribution. It is black in colour, with a greyish band across the back, and this permits its easy identification from other members of the family. The length is 7–9 mm.; larva is brown and hairy, and approximately 10–12 mm. long.

The insect is found on bran, thirds, dog biscuits, rabbit skins, leather, cattle-food, pig meal, raw silk waste, flaked maize, soya meal, chick meal, ground nut flakes, nutted cake, palm kernel meal, milk meal, hound meal, grass meal, laying meal, cake cobettes, dairy cake, layer's pellets, balanced ration meal, grass cobettes, dairy meal, record yield meal, cotton cake, chick growing meal, cacao, nutmegs, dried peas, Indian gum damar, hides, tobacco, dried fish, hams, and bacon, and in warehouses. The larvæ are found on raw silk waste, rabbit skins, leather, dog biscuits, and many of the above-mentioned products.

Dermestes oblongus is comparatively rare, but there is the danger that it may become more widespread by transport of goods. It is black in colour, and about 7–10 mm. long. The larva, which is about 10–12 mm. long, is dark brown and hairy. The insect has been recorded on hides, raw silk waste, and sisal, and the larva on raw silk waste and sisal.

Attagenus pellio is oval in shape, black in colour, and about 5–6 mm. long. It has two distinct white spots on the back. The adult insect often appears

in large numbers in May and June, particularly on windows and window ledges, but during the remaining months of the year only isolated specimens are found, although the premises may be infested. The adult insect causes little damage; the damage attributed to this insect is caused by the larvæ, which are brown, about 8 mm. long, and characterized by long bushy tails.

This larva is present in nearly every house; in the attics there is always an accumulation of insect debris from spiders' webs, and the dead bodies of various insects which have died during hibernation, this proving a fertile breeding-ground for the Dermestid and Ptinid larvæ. Offices in warehouses, or the older type of large dwelling-houses which have been made into offices, are often invaded by large numbers of this beetle, causing serious inconvenience to the staff, who do not realize the harmless nature of this beetle to them personally. These invasions can always be traced to this accumulation of dried insect remains. The insect has been recorded on warehouse windows, walls and floors; in sugar, maize, flour, meal, cattle-food, skins, and furs; in houses, natural history collections, stable lofts, debris of haystacks and carpets.

Trogoderma granarium is known as the khapra beetle and is an important pest in grain. It is oval in shape, brown in colour, about 2 mm. long, and cosmopolitan in distribution. Larva is cream coloured, about 1½–2½ mm. long, and characterized by a bushy tail. The insect has been recorded on wheat and Indian barley and in warehouses; the larvæ on Indian grain,

grain sacks, wagons which have conveyed infested Karachi wheat, and cotton bales which had been alongside infested wheat during transit. Needless to say, this infestation caused serious alarm to the management in the cotton mills.

Tenebrionidæ

The Tenebrionidæ family comprises over 10,000 species, but only a few are found to attack stored products in this country. There are wide divergencies in size between the different members.

Blaps mucronata is known as the churchyard beetle, and appears to be European in distribution. It is black, and about 18–22 mm. long. Larva is pale ferruginous colour, similar to that of *Tenebrio molitor*, but larger. The insect has been found in warehouses, stocks of glass bottles, cellars, stables, kitchens, churchyards, and bakeries.

Tenebrio molitor is black in colour, cosmopolitan in distribution, and about 12–16 mm. long. The larva of this pest, which is known as the yellow meal worm, is about 25–30 mm. long, and yellow in colour. The larval stage is about two years or longer, according to temperature. The insect has been found on wheat, bran, thirds, flour, meal, and old flour, and is reputed to be injurious to ground cereals, especially when stale ; it is found also on ships' biscuits. Larvæ are found on rice meal, oat feed, pollards, bran, malt culms, flour, thirds, empty sacks, on warehouse floors, and in crevices between floorboards, and often do serious damage in ships' biscuits. The larvæ have also been found in association with the death

watch beetle, destroying old oak beams in houses and churches.

Tenebrio obscurus is cosmopolitan in distribution, black in colour, and about 12–16 mm. long. The larva is known as the dark meal worm, and is browner in colour than that of the *Tenebrio molitor*, and about 25–30 mm. long. The larval stage is 2 years or more, according to temperature and food supply. The insect has been found on pollards, old flour, meal, and ground cereals, and in flour mills; the larva in crevices between floorboards and in ground cereals.

Alphitobius diaperinus is dark brown in colour, about 5–5½ mm. long, and cosmopolitan in distribution. The larva is known as the lesser meal worm, and is pale ferruginous in colour beneath and darker above, with central part of each segment darker except for the middle line; it is approximately 8–10 mm. long. The insect has been recorded on hides, rice meal, cattle-food, pig meal, flour, chick feed, calf cobettes, calf meal, cacao, Indian gum damar, cereals, linseed, cotton seed, chocolate, ground nuts, tobacco; the larvæ on rice meal. The beetle and its larvæ abound in some of the stables in deep, hot coal mines, living on the horses' food.

Alphitobius lævigatus is dark brown in colour, cosmopolitan, and about 4–5 mm. long. It is also known as *Alphitobius piceus*. The larva is 7–9 mm. long, and very similar to that of *Alphitobius diaperinus*, and has been taken on old flour. The insect is recorded on soya beans, flour, cereals, linseed, cotton seed, ground nuts and tobacco, and in granaries.

FIG. 24.—*Attagenus pellio L.* larva. × 4.

FIG. 25.—*Attagenus pellio L.* adult. × 6.

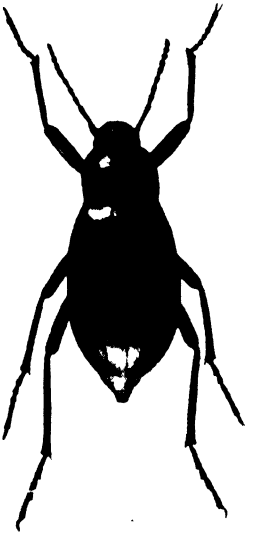


FIG. 26.—*Blaps mucronata Latr.* × $1\frac{1}{6}$.

[*To face page* 16.

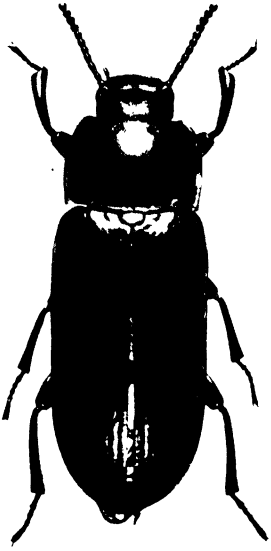


FIG. 27.—*Tenebrio molitor L.* adult. × 4.

FIG. 28.—*Tenebrio molitor L.* larva. × 3.

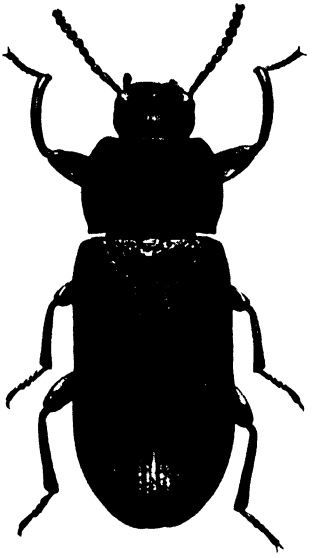


FIG. 29.—*Tenebrio obscurus F.* × 4.

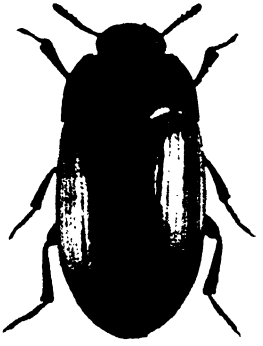


FIG. 30.—*Alphitobius diaperinus Panz.* × 6.

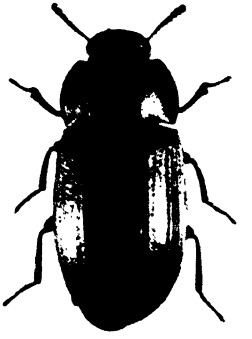
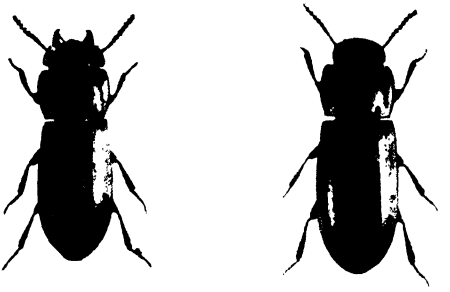


FIG. 31.—*Alphitobius lævigatus F.* × 6.



Gnathocerus cornutus F. × 6.
FIG. 32, left, male; FIG. 33, right, female.

FIG. 35. *Tribolium confusum Duv.* × 6.

FIG. 34. — *Tribolium castaneum Hbst.* × 6.

To face page 17.]

(See also Frontispiece)

Gnathocerus cornutus is reddish brown in colour and about 4–5 mm. long. It resembles *Tribolium castaneum* and *Tribolium confusum* in colouring, but is longer and broader. The male can be readily distinguished from the female by the small horns which project from the vertex of the head, and by the enlarged mandibles, which are very prominent, with recurved acute tips resembling horns. This is well shown in the photographs of the sexes. The insect is recorded on thirds, bran, sharps, flour, wheat, broad bran, rice meal, layer's pellets, laying meal, grass meal, grass cobettes, dairy cake, balanced ration meal, cake cobettes, record yield meal, dairy meal, chick meal, chick-growing meal, cotton-cake, ginger, meal, bread, and ground cereals, and in cacao and spice warehouses and bakeries.

Tribolium castaneum is commonly known as the red rust flour beetle. It is reddish brown in colour, approximately 3–4 mm. long, and cosmopolitan in distribution. It is distinguished from *Tribolium confusum* by the antennæ. In *Tribolium castaneum* the antennæ are abruptly club-shaped, but those of *Tribolium confusum* thicken more gradually. Larva is linear, slightly narrowed towards apex, reddish yellow above, paler beneath; 5–6 mm. long.

The insect is recorded on rice meal, wheat, empty sacks, rice, dog biscuits, cattle-cake, cotton seed meal, bran, thirds, oats, wool, maize, dairy meal, seconds, grass meal, ground oats, maize meal, flour, ground nut flakes, old sacking, grass nuts, ground biscuits, cotton waste, cattle food, pig meal, laying meal, grass cobs, rolled oats, calf meal, milk cobs, poultry

feed, malt culms, French seconds, Australian flour, soya beans, layer's pellets, cake cobettes, dairy cake, balanced ration meal, grass cobettes, record yield meal, chick meal, cotton cake, chick-growing meal, linseed flakes, middlings, cotton, wheat meal, Karachi wheat, cacao, nutmegs, chillies, almonds, seed tapioca, sultanas, figs, sacks of rubber, Indian gum damar, stored cereals, lentils, butter beans, arachis, dried fruit and lac, and on warehouse walls and floors; the larvæ on rice, rice meal and wheat. It is a general feeder injurious to cereals in every form.

Tribolium confusum is known as the confused flour beetle. It is cosmopolitan, reddish brown, and approximately 3½–4½ mm. long. It has been recorded on rice meal, wheat, tanning extract, rice, maize, flour, ground nut cake, cotton, bran, thirds, oats, seconds, maize meal, dairy meal, sharps, rolled oats, ground oats, French seconds, old sacking, ground nut flakes, wheat screenings, pig meal, fattening meal, grass nuts, grain sweepings, ground biscuits, grass meal, cotton waste, cattle food, poultry food, dairy nuts, laying meal, grass cobs, calf meal, milk cobs, poultry feed, half corns, malt culms, grower's mash, Australian flour, chick feed, calf cobettes, winter meal, soya beans, layer's pellets, cake cobettes, dairy cake, balanced ration meal, grass cobettes, record yield meal, chick mash, chick-growing meal, cotton cake, linseed flakes, middlings, balanced dairy meal, baskets, Karachi wheat, pig food, fattening nuts, cacao, beans, corn, biscuits, cashew nuts, ground nuts, in a cacao warehouse, and on warehouse walls

and floors ; the larvæ on flour, wheat and rice meal. It is a general feeder, injurious to cereals in all forms.

Tribolium destructor is becoming cosmopolitan in its distribution. It is blackish brown in colour, very strongly punctured, which causes it to appear dullish on the surface, and is 10–12 mm. long.

The larva is light-brownish in colour and about 12 mm. long and because of its larger size it is probably more destructive than the larvæ of other Tribolium species. (See Frontispiece.)

It is found on cereals and cereal products.

Palorus ratzeburgi is very similar to *Tribolium*, both in colour and shape, but is smaller (2½–3 mm. long). It occurs in granaries and bakeries, amongst flour and meal, but is not common.

Palorus subdepressus is separated from *Palorus ratzeburgi* by the more strongly and closely punctured sides of thorax ; it is approximately 2½–3 mm. long, is not common, but occurs in granaries, bakeries and shops among flour and meal.

Latheticus oryzæ is known as the short-horned flour beetle and as the long-headed flour beetle. It is cosmopolitan, reddish brown in colour and about 2½ mm. long. It does not appear to be so prevalent in stored products as other members of this family, but has been recorded on wheat, rice, barley, and flour and in warehouses.

Cryptophagidæ

A number of members of the *Cryptophagidæ* are found associated with stored products, but as a

general rule the quantity of insects found is not large.

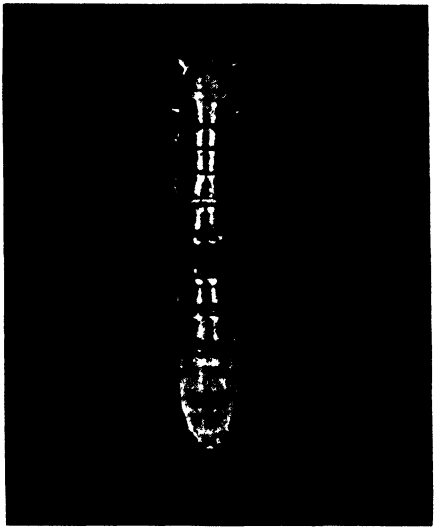
Cryptophagus saginatus is brown in colour and about 2–2½ mm. long; it is found in Europe and North America. It has been found on hops, warehouse sweepings, sultanas, warehouse walls, and in the open in decaying vegetable matter.

Cryptophagus fowleri is distributed throughout Europe. It is brown and about 2–2½ mm. long, and has been recorded on sharps, thirds, rolled oats, maize germ meal, decaying vegetable matter and damp warehouse walls.

Cryptophagus pallidus is brown in colour, about 2–2½ mm. long, and European in distribution. It has been found on barley, decaying vegetable matter and damp warehouse walls.

Cryptophagus acutangulus is found in Europe and North America. It is 2–2½ mm. long, and brown in colour. It is recorded in bakeries, granaries, decaying vegetable matter, warehouses, and on damp warehouse walls.

Cryptophagus cellaris appears to be the commonest member of this family found on stored products. It is almost cosmopolitan in distribution, brown in colour, and about 2–2½ mm. long. It has been found on wheat, flour, bran, seconds, ground linseed cake, sharps, barley meal, rolled horse corn, grass meal, chaff, meal, middlings, cattle-food, rolled oats, broad bran, barley, oats, decaying vegetable refuse, bread, Australian sultanas, in cellars, and on damp walls of warehouses. The species of *Cryptophagus* are generally associated with dampness, feeding on the



Palorus ratzeburgi WISS., FIG. 36, left, adult. × 6 : FIG. 37, larva. × 13.

FIG. 38, below, *Palorus subdepressus* WOLL. × 6.

FIG. 39. *Latheticus oryzæ* WAT. × 6.

[To face page 20.

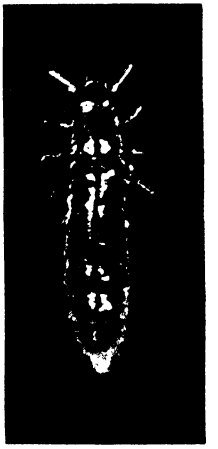
FIG. 40.—*Cryptophagus vaginatus Sturm.* × 6.

FIG. 41.—*Cryptophagus fowleri Joy.* × 6.

FIG. 42.—*Cryptophagus pallidus Sturm.* × 6.

FIG. 43.—*Cryptophagus cellaris Scop.* × 6.

FIG. 44.—*Cryptophagus acutangulus Gyll.* × 6.



Oryzæphilus surinamensis L. FIG. 46, left, adult. × 6; FIG. 47, right, larva. × 3.

FIG. 45.— *Læmophlæus ferrugineus Steph.* × 6

FIG. 48. *Oryzæphilus mercator Fauv.* × 6.

PLATE 16

Ahasverus advena Watl. FIG. 49, left, larva. × 13; FIG. 50, right, adult. × 6.

FIG. 51.—*Lathridius bergrothi Reit.* × 6.

FIG. 52.—*Lathridius nodifer Westn.* × 6.

To face page 21.]

moulds and other fungoid matter which are always found accompanying damp conditions, so that good storage conditions which exclude all dampness form the best preventative against these beetles.

Cucujidæ

Only a few members of the *Cucujidæ* family attack stored products.

Læmophlœus ferrugineus is known as the red rust grain beetle. It is cosmopolitan, reddish brown in colour, and about 2 mm. long. The larva is long, narrow and pale in colour, with two rather strong hooks on the last segment; it is probably beneficial, living as it does on the larvæ of other grain pests. The species has been found in maize, poultry food, wheat, rolled oats, broad bran, oats, currants, cacao, chillies, Indian gum damar, bark, wasps' nests, and in European granaries.

Oryzæphilus surinamensis is called the saw-toothed grain beetle. It is cosmopolitan in distribution, about 3–3½ mm. long, and blackish brown in colour. It is recorded on barley, flour, rice, maize, bran, barley meal, thirds, rice-meal, seconds, cattle-food, straw, ground nut flakes, wheat, sugar, sultanas, currants, raisins, dates, dried peas, mace, cacao, figs, and amongst sugar; the larvæ have been found in Australian sultanas.

Oryzæphilus mercator is very similar to *surinamensis*, but has larger eyes and more transverse apical joints to the antennæ; it is 3–3½ mm. long. Its habits resemble those of *Oryzæphilus surinamensis*, but it is not so common; similar commodities are affected.

Ahasverus advena is known as the foreign grain beetle. It is cosmopolitan, about 2–3 mm. long, and brown in colour. It is recorded on wheat, maize, cacao, ginger, nutmegs, bulbs, herbs, algaroba pods, yams, pine-nuts, meal and flour.

Lathridiidæ

All the members of the *Lathridiidæ* family are minute insects.

Lathridius bergrothi is European, reddish brown in colour, and about 2 mm. long. It has been recorded on warehouse walls.

Lathridius nodifer is a blackish beetle with raised humps on the elytra ; it is about 2 mm. long. It is cosmopolitan in distribution, and common in stores and warehouses, especially if these are inclined to be damp.

Enicmus minutus is cosmopolitan, dark reddish brown in colour, and 1¼–2¼ mm. long. There are records of its presence on wheat, barley, haystack and other refuse, moss, wood stacks, and damp walls of warehouses.

Cartodere elongata is pale ferruginous in colour and 1⅛–1⅖ mm. long ; it is widely distributed in granaries and hay stores.

Corticaria elongata is European, yellowish-brown in colour, and about 1⅓–1½ mm. long. It has been found on warehouse walls, under bark, in ants' nests, in haystack refuse, and in decaying vegetable matter.

Carabidæ

The members of the *Carabidæ* family—in both the larval and adult stages—are carnivorous, but there

are instances recorded where they have caused damage to grain and seeds.

Bradycellus harpalinus is about 4–4½ mm. long and brown in colour, with a shiny surface. It is a European species. It is predaceous on other insects, larvæ and mites, and has been recorded on meal infested by mites.

Læmostenus terricola is about 13–15 mm. long, and black in colour, with a cyaneous tinge. It is a European species and has been found on infested cattle-feeding nuts. It is predaceous on other insects, larvæ and mites.

Læmostenus complanatus is slightly smaller than *Læmostenus terricola*, is 12–14 mm. long, and is frequently mistaken for it ; it is of a more parallel-sided shape, and black without the bluish reflection. It has been spread world-wide by commerce. It is also predaceous on other insects, larvæ and mites, and has been taken in granaries, stores, glue and chemical works amongst infested material.

Staphylinidæ

There are over 14,000 species in this family, of which over 800 inhabit the British Isles. Most of them are associated with decaying vegetable matter, and a few are predaceous. Fortunately, few of them attack stored products.

Atheta trinotata is about 3 mm. long, black with yellowish elytra. It is European in distribution, predaceous on larvæ and mites, and has been recorded on wheat and on decaying vegetable matter.

Oligota granaria is deep black in colour and about

1 mm. long. It is European in distribution. It is recorded on Japanese cotton goods and in cellars, especially in damp cellars where mould is growing, and it is usually associated with the species *Cryptophagus*, *Mycetæa* and *Lathridius*.

Xylodromus concinnus is also European. It is dark brown in colour, about 3 mm. long, very flat in shape, and recorded on thirds, sharps, corn meal, wheat, grain, straw, ground wheat, decaying vegetable matter and in warehouses.

Endomychidæ

Mycetæa hirta is cosmopolitan, about 1–1¼ mm. long and reddish brown in colour, clothed with pale, coarse, somewhat setose hairs. Larva is a small, elongate, yellowish white grub. Recorded in haystack refuse, corn-bins, cellars, Japanese cotton goods, and wine cellars, where the larvæ bore into wine corks and frequently do considerable damage.

Nitidulidæ

Carpophilus hemipterus is a stoutly built, convex, dull pitchy black species with a yellowish mark at shoulder of elytra and another at apex, which latter occasionally covers the apical half; thorax with hind margin straight. It is 2½–3 mm. long, and is cosmopolitan in distribution. The larva is yellowish white, parallel sided, and rather curved, feeding in ground nuts and dried fruits. It is found in sugar, figs, dried fruits, grain, ground nuts, preserved ginger.

Carpophilus ligneus is very similar to *hemipterus*, but without the distinct yellowish marks on elytra, and

FIG. 53. *Enicmus minutus L.* × 6.

FIG. 54. — *Cartodere elongata Curt.* × 6.

FIG. 55. *Corticaria elongata Gyll.* × 18.

[To face page 24.

FIG. 56.—*Læmostenus complanatus Dej.* × 2.

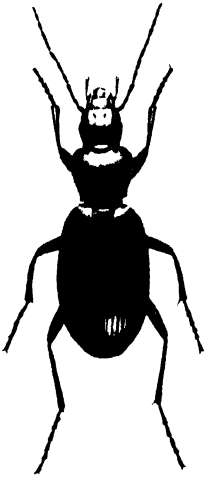


FIG. 57.—*Læmostenus terricola Herbst.* × 2.

FIG. 58. *Myceteа hirta Marsh.* × 6.

FIG. 59.—*Bradycellus harpalinus Serv.* × 6.

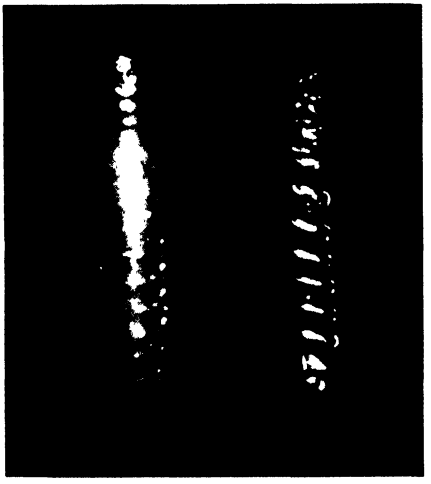
FIG. 60. *Atheta trinotata Kraatz.* × 6.

FIG. 61. *Oligota granaria Er.* × 18.

FIG. 62.—*Xylodromus concinnus Marsh.* × 6.

FIG. 63.- *Carpophilus hemipterus L.* 6.

Carpophilus ligneus Murray. FIG. 64, above, adult. - 6 ; FIG. 65, left, larvæ. - 15 ; FIG. 66, right, pupæ. - 15.



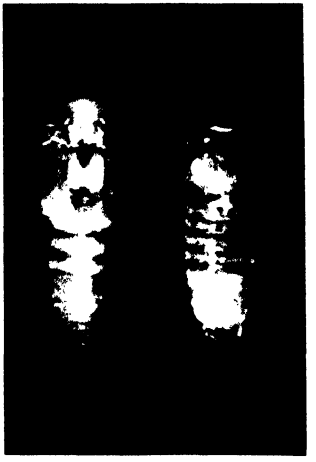


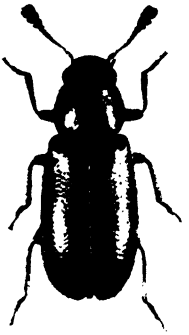
FIG. 68. — *Carpophilus mutilatus Et.* × 6.

FIG. 67. *Carpophilus dimidiatus. F.* × 6.

Tenebroides mauritanicus L. FIG. 69, left, adult. × 6 ; FIG. 70, right, larva. × 6.

PLATE 22

FIG. 71. *Typhæa stercorea L.* × 6.



Necrobia rufipes De G.
FIG. 72, left, adult. × 6;
FIG. 73, below, larva. × 3.

FIG. 74.—*Necrobia violacea L.* × 6.

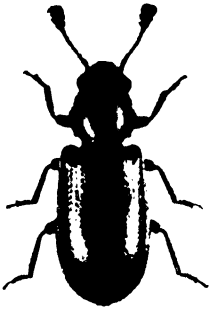


FIG. 75. *Necrobia ruficollis F.* × 6.

FIG. 76.—*Corynetes caeruleus De G.* × 6.

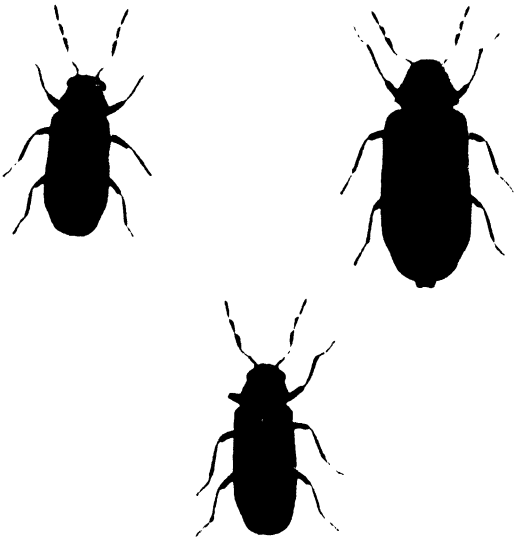


FIG. 77. *Anobium striatum Ol.* × 7, showing, left, male; right, female; and below, underside of male.

To face page 25.]

with the thorax rounded on hind margin. It is 2–3 mm. long, and cosmopolitan. It has been found in dried prunes, nuts, raisins, and grain.

Carpophilus dimidiatus is a larger insect, dull pitch brown, with base of thorax almost straight, and sides more parallel, with very little narrowing at front margin as in the two previous species. It is 3–4 mm. long and cosmopolitan. Found in preserved ginger, dried fruits, nuts, hides, cocoa, nutmegs, sultanas, dates, wheat, drugs, earthnuts, cornmeal.

Carpophilus mutilatus is the smallest species, reddish brown to dull brownish black, with a pale band on each elytron from shoulder to suture making a wide-angled V mark; the thorax is straight on hind margin, with sides rounded very gradually, the front margin almost as broad as hind margin—these differences are well shown in the photographs. It is 2–2½ mm. long and cosmopolitan. Found in pea nuts, grain and dried fruits.

Trogositidæ

Tenebroides mauritanicus is known as "the Cadelle." It is black, about 8 mm. long and cosmopolitan. Although it damages stored products, this is counterbalanced by the fact that it is predaceous on other insects, larvæ and mites. The larva is about 10 mm. long, white in colour, head blackish brown; last segment brownish black with two spines. Found on bran, thirds, ground nut cakes, seconds, biscuit meal, wheat, oats, pinhead oatmeal, maize, flour, pig meal, soya beans, middlings, cereals and other seeds, nut-

megs, cacao, Australian currants and sultanas. Larvæ are found on these products.

Mycetophagidæ

Typhæa stercorea is sometimes called the haybug. It is found in Europe and North America, is light brown in colour and about $2\frac{1}{2}$–$2\frac{2}{3}$ mm. long. Recorded on oats, flour, empty sacks, maize germ meal, rolled oats, sharps, rolled horse corn, flat corn meal, chick mixture, Plate maize, barley meal, biscuit meal, wheat, poultry food, bran meal, maize meal, oatmeal, bean meal, horse corn, bran, warehouse floors, soya beans, feeding nuts, grass nuts, granary refuse and cacao, and in a spice warehouse. Larva is linear, rather depressed, of a pale whitish brown colour.

Cleridæ

Necrobia rufipes is cosmopolitan in distribution. It is $3\frac{1}{2}$–4 mm. long and bluish-black in colour, with red legs. Larvæ are predaceous on other larvæ. Recorded on oats, maize, hides, dog biscuits, laying meal, Japanese cotton goods, ground nut flakes, raw silk waste, stored hams, cacao, nutmegs, figs, cowries, copra, skins, fatty matter, warehouse walls and floors.

Necrobia violacea is of an entirely cyaneous colour with black legs ; the upper surface is clothed with long soft black hair. It is $3\frac{1}{2}$–4 mm. long. The larvæ are predaceous on other larvæ and mites. Recorded on similar products to *Necrobia rufipes*, and is cosmopolitan in distribution.

Necrobia ruficollis is readily distinguished from the

other two species by its entirely red head and base of elytra and bright red legs. The upper surface is covered with long soft black hairs. Is 4½–5 mm. long. Larvæ are predaceous on other larvæ and mites. Found under similar conditions to the other two species, and often the most abundant.

Corynetes cœruleus is very similar in size and colour to *Necrobia violacea*, but has the club of the antennæ narrower, and loose and not compact like that of the three *Necrobias*. It is entirely cyaneous in colour, with black legs and antennæ. It is 3–4 mm. long. The larvæ are predaceous on other larvæ, and frequently on those of *Anobium*. Found under similar conditions to *Necrobia* and is widely distributed.

Anobiidæ

Anobium striatum is known as the common furniture beetle. It is dull fuscous brown in colour, about 3–4 mm. long and cosmopolitan. The males are distinguished by their longer antennæ. Larvæ white, stout-bodied and more or less curved. Recorded in deal, pine, oak, beech, alder, willow, old wood, warehouses, old buildings.

Stegobium paniceum was formerly known as *Anobium paniceum*, but is readily separated from the furniture beetle by the shape of the head and thorax; it is pale reddish in colour, shining, clothed with greyish pubescence. The sexes are similar, with the exception that the male has longer antennæ. It is approximately 2–3 mm. long. The larvæ are very similar to those of *Ptinus fur*, the same whitish semi-circular shape with brown head, and are found in

biscuits and other products of a cereal nature. It was formerly abundant in ships' biscuits, and the insects were known as "weevils" by sailors. Cotton cake is sometimes riddled by this beetle and its larvæ, and it has occurred in various brands of soup tablets. Toys made from the compressed pulp of waste cotton seeds are often attacked by this beetle, and it has caused consternation in houses where it was confused with the furniture beetle. This species has not been known to attack wood of any kind.

Lasioderma serricorne is known as the tobacco beetle or cigar beetle. It is cosmopolitan, of a reddish testaceous colour, rather shining, clothed with fine greyish hairs; antennæ with first joint very large, the remainder finely but distinctly serrate. It is about 2 mm. long. The larvæ are stout white fleshy grubs, abdomen curved and swollen. It infests a variety of stored foods, ginger, liquorice, cigarettes, cigars, tobacco, etc. It is stated that in Mexico they have evolved a method of controlling this pest in the cigar factories by Röntgen rays.

Bostrychidæ

Rhizopertha dominica is called the lesser grain borer. It is a cosmopolitan insect, brown in colour, and 2 mm. long. The larvæ are whitish, narrower in outline than those of *Anobiidæ*. Recorded in wheat, corn, rice, flour, drugs, packing cases and boxes, floors of warehouses; larvæ found in Karachi wheat.

Lyctidæ

This family consists of wood-boring insects which attack both freshly cut and old timber. There are

FIG. 78. *Anobium striatum Ol.*, larvæ and pupæ.

[*To face page* 28.

Stegobium paniceum L. FIG. 79, left, adult. × 6 ; FIG. 80, above, larva. × 6 ; FIG. 81, below, beetle and larvæ in soup tablet.

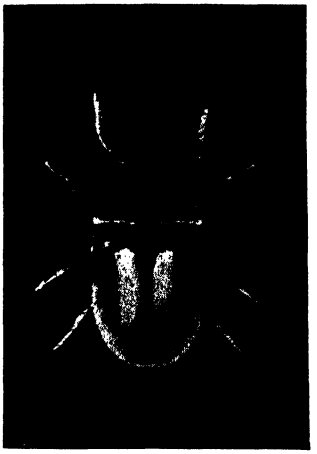


FIG. 82. *Lasioderma serricorne F.* × 10.

Rhizopertha dominica F.
FIG. 83, below, larva. × 13;
FIG. 84, right, adult. × 6.

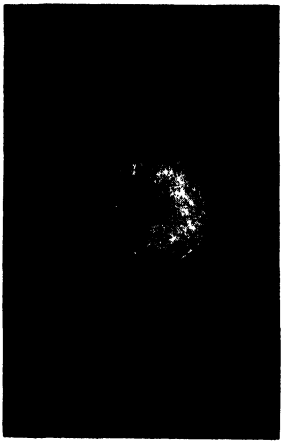


FIG. 86. *Lyctus brunneus Steph.* × 6.

FIG. 85. *Lyctus linearis Goeze.* × 6.

FIG. 87.—*Lyctus planicollis Le C.* × 6.

FIG. 88.—*Lyctus parallelopipedus Mels.* × 6.

FIG. 89.—*Lyctus sinensis Lesne.* × 6.

To face page 29.]

five species known to occur in this country, and they are called powder post beetles.

Lyctus linearis is brown in colour and about 3–5 mm. long; cosmopolitan in distribution. The larvæ are very similar to those of *Anobiidæ*, but relatively stouter on the fore-part of the body. It is found in most hard woods and in furniture.

Lyctus brunneus is brown in colour, about 3–5 mm. long, and cosmopolitan. The larvæ are similar to those of *Lyctus linearis*. It is found in furniture, oak, mahogany, walnut, sweet-chestnut, elm, ash, hickory, sycamore; recorded in most hardwoods and known to attack green timber, but pine and other coniferous timbers are not known to be attacked by these beetles.

Lyctus parallelopipedus is a darker brown species, rather smaller in size, 3–4 mm. long and cosmopolitan in distribution. It attacks hard woods in timber yards, and also in office fittings and furniture.

Lyctus planicollis is brown to dull black in colour, very variable in size, and ranges from $2\frac{1}{2}$ to 5 mm. long. This species can generally be recognized by its almost black colouring and wide range in size; all the species of *Lyctus* are variable in size, but this species has the greatest range. It is cosmopolitan in distribution. The larvæ are similar to the other *Lyctus* larvæ. It attacks similar woods.

Lyctus sinensis is a pale yellow brown species with a dark brown suture to the elytra, and 3–4 mm. long. The larvæ are similar to the other *Lyctus* larvæ. It has only recently been found attacking furniture made from Japanese oak.

Cerambycidæ

Gracilia minuta is a European species and 3½–5 mm. long. It is a small brownish beetle, linear, depressed, dull, with antennæ longer than body in male and about as long as body in the female. The larvæ are white, fleshy, long, with second segment much enlarged, living in dried twigs of hazel. The species is often found in old baskets, hampers, and skips; goods stored or conveyed therein are liable to infestation. It has been found on yarns and clothing conveyed in baskets.

Leptidea brevipennis also is a European species. It is entirely pitchy to pitchy red, antennæ shorter than body in both sexes; a smaller, more linear insect than *Gracilia minuta*, though very similar in appearance. The larvæ are dirty white, with prothorax enlarged, chiefly found in old willow baskets. Not uncommon in cotton mills where willow baskets and skips are used for conveying and storing cotton and cotton goods, but will not damage the goods in any way.

LEPIDOPTERA

THE *Lepidoptera* group comprises the moths and butterflies, and the life cycle is similar to that of the beetle, *viz.*, egg, larva, pupa and mature insect. Considerable damage is done to stored products by this group, but the larva is the sole cause of the damage, and not the mature insect. The flying

habit of the mature insects permits rapid spread of the infestation, because they deposit eggs on adjacent stocks.

Those moths which infest wool and hair cause no damage in the adult stage, the whole of the damage being caused by the larvæ. The larvæ of moths do not as a general rule attack whole grain, but they can feed on broken grain. They cause serious damage to cereal products such as flour, meals and prepared cattle and poultry foods. The material becomes contaminated by their excreta, and they form webs and tubes of silky material within the flour and meal.

About 80,000 species of Lepidoptera have been described, but only a small proportion are injurious to stored products.

Phycitidæ

Ephestia kuehniella is known as the Mediterranean flour moth, and is widely distributed. It is of a drab grey or mouse grey colour, sprinkled with dark fuscous scales with two lines crossing the upper wings ; hind-wings are greyish-white, with veins fuscous. It is 22–25 mm. long. The larva is whitish in colour, second segment with two pale brown plates, dark hairs rising from small chitinized spots on each segment. Adult and larvæ are recorded on barley meal, seconds, flour, meal, bran, middlings, maize meal, thirds, potatoes, cacao, biscuits, cereals and cereal products, rice flour, buckwheat flour, rye, rye meal, oatmeal, macaroni, soya beans, chocolate, cotton seed, hemp seeds, sesame seeds, dried mushrooms, walnuts, almonds, peas, beans, peanuts, acorns,

chillies, chestnut flour, dried chestnuts, jelly cubes, dead insects.

Ephestia cautella is called the fig moth and dried currant moth, and is a widely distributed species in dried fruits. It is of a lighter or darker drab colour, with two faint oblique lines crossing fore-wings bordered with a whitish suffusion. Hind-wings are whitish margined with grey. It is 15–22 mm. long. The larvæ are whitish, suffused with pink or ochreous, two plates on second segment dark brownish, and the small chitinous plates on each segment of a dark brown colour. Adults and larvæ are recorded from docks and warehouses, on dried poppy petals, olive fruits, almonds, rice, cake chocolate, cacao-beans, chocolate bonbons, cotton seed, cotton cake, currants, sultanas, raisins, dried apples, dates, pomegranates, pears, citrus fruits, asparagus berries, tonka beans, gall-nuts, ground nuts, locust beans, chick pea, almonds, walnut, pecan nuts, biscuits, flour, bran, maize meal, hominy, oatmeal.

Ephestia elutella has been called the Cocoa moth, but it is found on a wide range of other products. It is of a grey colour with whitish and dark fuscous scales mixed, often with a sprinkling of pale reddish scales. Two faint pale lines, dark edged, the first rather oblique and the second straight, cross the fore-wings. The hind-wings are pale fuscous, narrowly margined with grey. Length 15–22 mm. The larvæ are whitish brown with brown dots. Head and plate of second segment reddish brown. It has been recorded on biscuits, dried vegetables, tobacco, cayenne pepper, coffee, cacao, ground nuts, rice, seeds of

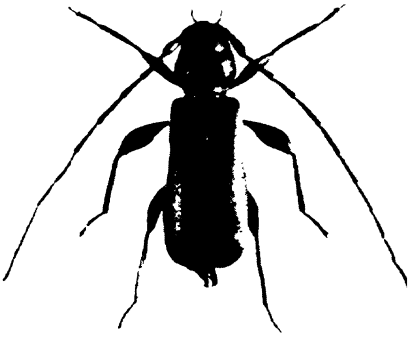


FIG. 90. *Gracilia minuta F.* × 6.

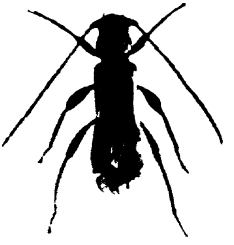


FIG. 91. *Leptidea brevipennis Muls.* × 6.

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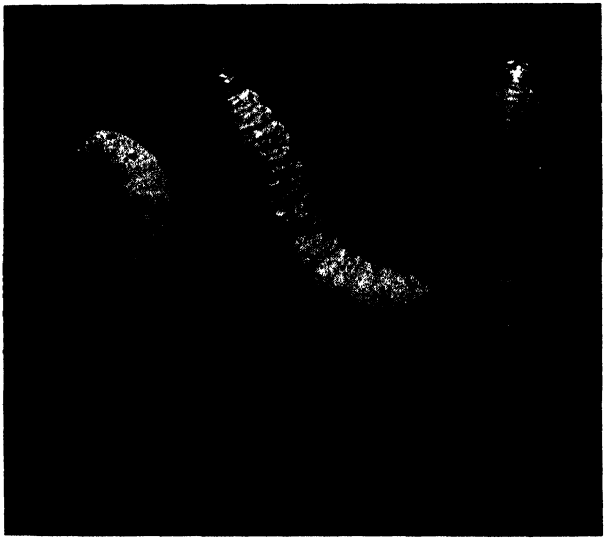


Ephestia kuehniella Zell. FIG. 92, at top, moth. × 4; FIG. 93, below, larvæ. × 3.

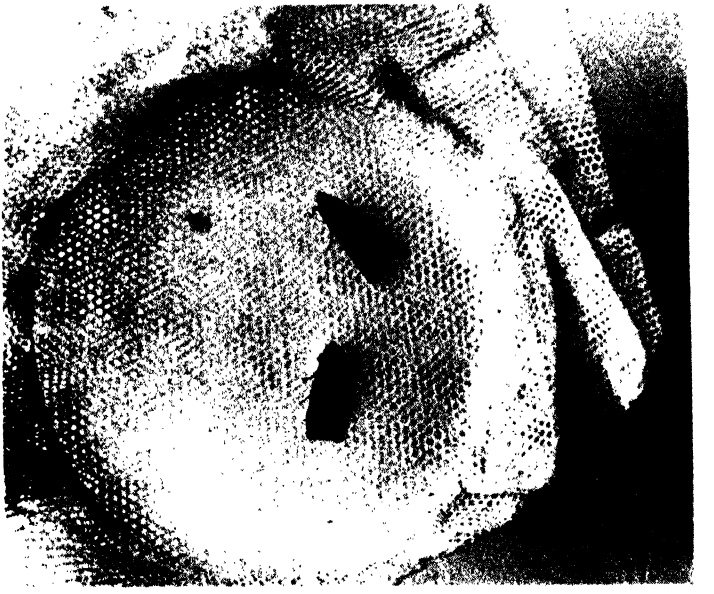
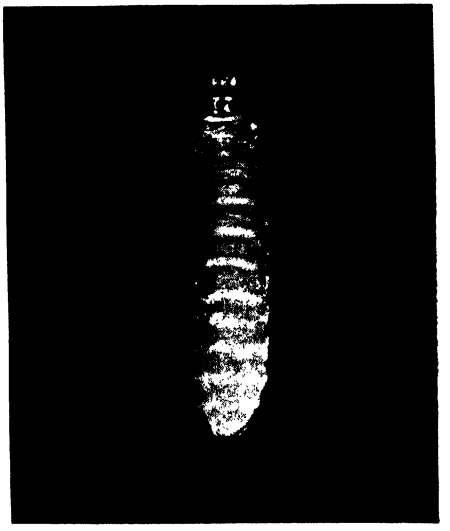


FIG. 94.—*Ephestia kuehniella Zell*, moths *in situ*, actual size.

Ephestia cautella Wlk. FIG. 95, at top, moth. × 4 ; FIG. 96, below, larva. × 3.



Plodia interpunctella Hubn.

FIG. 97, at top, moth. × 4 ;
FIG. 98, below, larva. × 3.

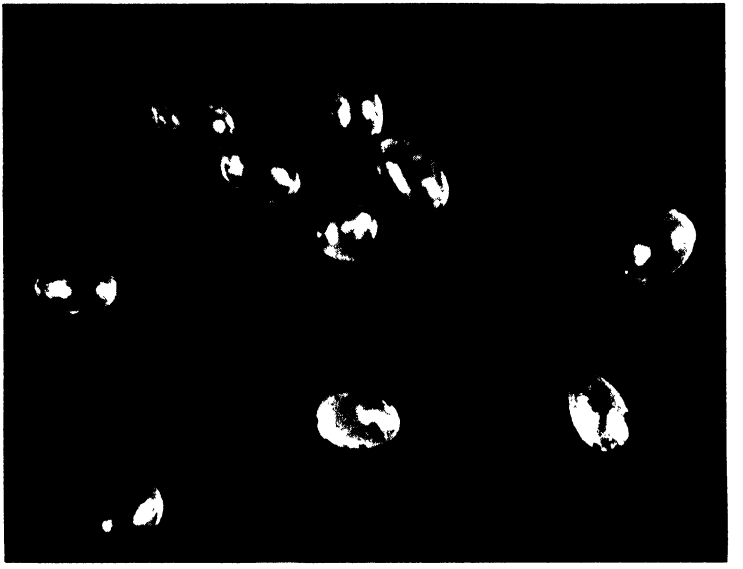


FIG. 99.—Eggs of *Borkhausenia pseudospretella Staint.* × 20. Compare with those below.

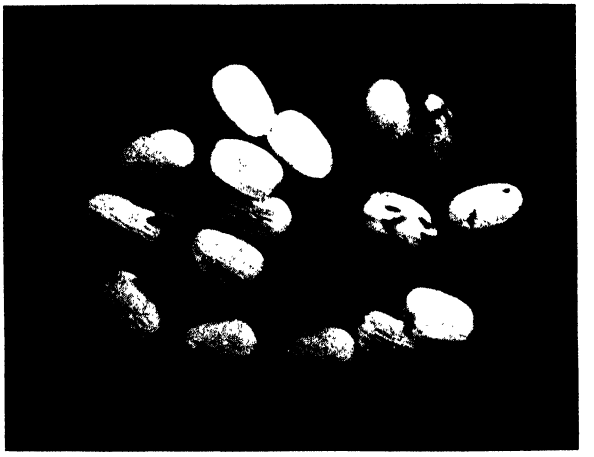
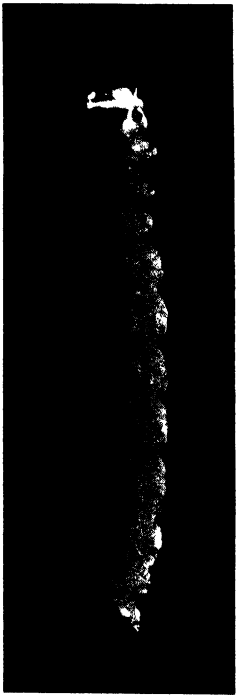


FIG. 100.—Eggs of *Dasycera sulphurella F.* × 11, shown for comparison with those above.

Borkhausenia pseudospretella Staint. FIG. 101, above, moth. × 3. FIG. 102, right, larva. × 5. For eggs see Fig. 99.



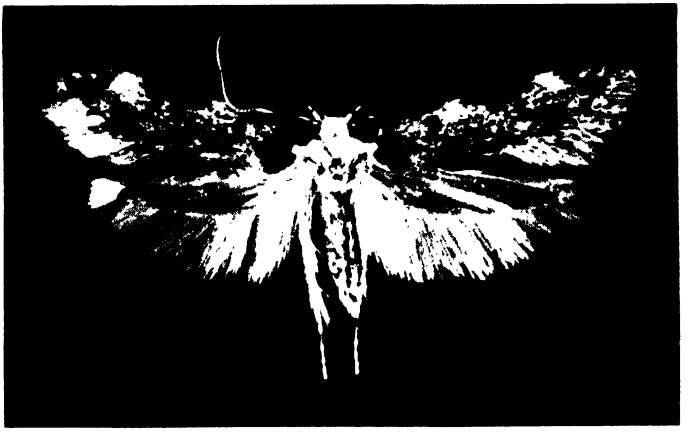


FIG. 103. *Endrosis lactella Schiff.* × 4.

FIG. 104. *Tinea lapella Hubn.* × 4.

sugar beet, dried pomegranate root, chicory, drugs, dried mushrooms, dried apples, dried cherries, dried hips and haws, dried rose petals, figs, almonds, nougat, flour and stored grain, dates, thatch and haystacks.

Ephestia calidella is another of the fruit pests, and is so closely related to *Ephestia cautella* that it is difficult to define differences without actual comparison of the examples; it has the same lighter to darker drab colorations, and similar indefinite oblique lines crossing the fore-wings. It is 19–24 mm. long. The larva is whitish pink in colour, with weaker chitinized spots from which the hairs arise. Adults and larvæ are often troublesome on dates, nuts, locust beans, figs, currants, raisins, almonds, cork, and dried insects.

Ephestia figulilella is also a dried-fruit pest, and was first described by Gregson from warehouses in Liverpool in 1871. It is of a light drab, sometimes yellowish buff, and again is difficult to determine without actual comparison of the examples; it appears to be often confused with the previous two species, *Ephestia cautella* and *Ephestia calidella*. It is 15–20 mm. long. Adults and larvæ recorded on dates, currants, figs, raisins, cotton seed cake, oatmeal and rice meal, in cacao stores and in chemists' shops.

Plodia interpunctella is called the Indian meal moth, meal-worm moth, cloaked knothorn, compressed vegetable moth. It is cosmopolitan. Fore-wings with a whitish basal area to first cross line, then leaden grey to second line, thence to apex reddish-brown suffused with leaden grey; hind-wings whitish grey. It is 14–20 mm. long. The larvæ are a dull whitish colour with hairs on dorsum, not arising from chitinous

spots; otherwise very similar to those of *Ephestia*. Adult and larvæ are recorded on wheat, bran, flour, sultanas, currants, figs, prunes, dried peas, dried apricots, almonds, raisins, grain, pea-nuts, arachis, chillies, palm seed, chestnuts, nougat, dried billberry, seeds of stonepine, spruce, dried peaches, dried grapes, dried apple skins, dried bananas, dates, dried loganberries, dried cherries, pineapples, jellies, preserves, marzipan, walnuts, pecans, locust beans, beans, acorns, caraway seeds, clover seed, garlic heads, sliced beet, lupins, herbarium specimens, dandelion root, cinnamon bark, yeast cakes, rye, rice, maize, maize meal, malt, cakes, honey cakes, bread, biscuits, macaroni, old books, fur, dead insects, beehives, humble-bees' nests, and stored frames from bee-hives.

Œcophoridæ

Borkhausenia pseudospretella is known as the brown house moth and false clothes moth; it is cosmopolitan. The head is light brownish, fore-wings pale to dark brownish, irrorated with dark fuscous scales with three distinct blackish spots. Towards the apex of the wing is a series of blackish dots, following the contour of wing apex. Hind-wings whitish grey. It is 19–23 mm. long. Larvæ are whitish, head red brown with two plates on second segment of a pale ochreous colour. Adult is recorded on bran, thirds, cattle feeding cake and nuts, flour, wheat, maize, sharps, flaked maize, beans, dairy nuts, bean meal, oatmeal, grass nuts, chick food, rolled horse corn, Sussex ground oats, chick growing food, flat corn meal, seconds, dairy meal, cotton seed meal,

rice meal, laying meal, rolled oats, split flat corn, calf nuts, fattening nuts, chick baby food, shudes, feeding meal, wool, maize meal, screened linseed, feeding nuts, warehouse walls and windows, seeds, dried plants, dried skins, and in houses. Larvæ recorded on grass nuts, feeding nuts, oat feed, walls and floors of warehouses, seeds, dried plants, dried skins; very destructive in herbariums amongst the plants, and also in insect collections.

Endrosis lactella is called the white-shouldered house moth, and is cosmopolitan. Head and thorax white; fore-wings greyish ochreous irrorated with black and white scales; 14–20 mm. long. Larvæ are whitish, head brownish with two pale plates on second segment, hairs on dorsum longer than in the other species of house moth caterpillars. Adult recorded on oats, peas, flour, beans, chaff, barley meal, wheat, maize meal, oatmeal, dairy nuts, flaked maize, laying meal, cattle feeding cake and nuts, split flat corn, cattle meal, cotton seed meal, cattle nuggets, lamb nuts, calf nuts, chick growing food, fattening nuts, old sacking, maple peas, linseed meal, sheep nuts, bean pickings, bean meal, fattening meal, dairy meal, ground nut flakes, barley, pinhead oatmeal, rye flour, grass meal, hop grass nuts, A.S. meal, calf meal, sheep and lamb nuts, feeding nuggets, A.S. nuggets, laying pellets, weaner's pellets, warehouse windows. Larvæ recorded on sheep nuts, grass meal, pinhead oatmeal, peas, beans, oat feed, broken wheat, old sacking, bean pickings, fattening nuts, middlings, feeding nuts, hop grass nuts, A.S. nuggets, A.S. meal, high yield meal, calf meal, dairy meal, feeding nuggets, sheep and

lamb nuts, chick-growing pellets, laying meal, weaner's pellets, sheep nuts, laying pellets.

Tineidæ

Tinea granella is known as the European grain moth. It is cosmopolitan. Head whitish, fore-wings whitish, irregularly irrorated with lighter and darker fuscous scales, with several darker marks, streaks and spots on upper surface. Hind-wings grey. It is 9–14 mm. long. Larvæ are yellowish-white, with pale brown head, and two plates on second segment of a paler yellow brown colour. Recorded on bran, sharps, in dried fruit warehouses; larvæ on figs, pistachio nuts and corn grains.

Tinea lapella is found in Europe and Asia Minor. Head ochreous-yellow; fore-wings pale yellowish, sprinkled with dark fuscous scales; hind-wings grey; it is 13–16 mm. long. The larvæ are whitish, with brown head and two brownish plates on second segment. Recorded on wool, rags, warehouse walls and windows, nests of birds and hair; larvæ on wool and rags.

Tinea pallescentella is called the large pale clothes moth. It is widely distributed. Head pale yellowish grey; fore-wings yellowish grey, with dark streaks and spots of fuscous scales; hind-wings fuscous white; 16–25 mm. long. The larvæ are whitish; head and plates on second segment reddish brown, found on wool, rags, warehouse walls and windows, in houses; larvæ on grain, wool, rags, and dried skins.

Tinea pellionella is called the case-bearing clothes moth, and is cosmopolitan. Head pale yellowish;

FIG. 105. *Tinea granella L.* × 4.

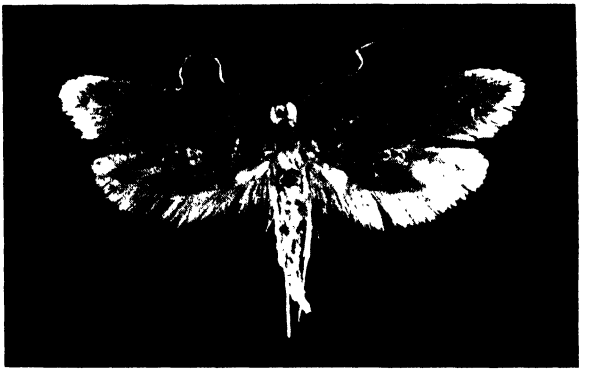
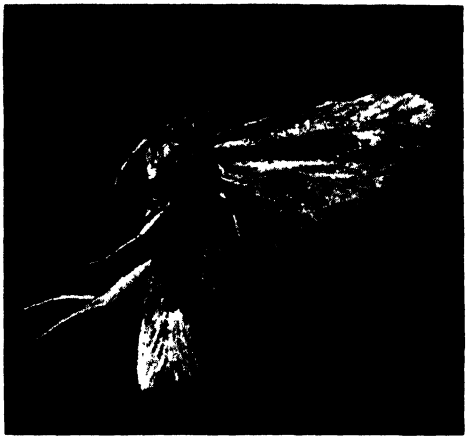


FIG. 106. *Tinea pellionella, L.* × 4.

[*To face page* 36.



Tinea flavescentella Haw. FIG. 107, at top, moth. × 3; FIG. 108, pupa and larvæ case. × 2½.

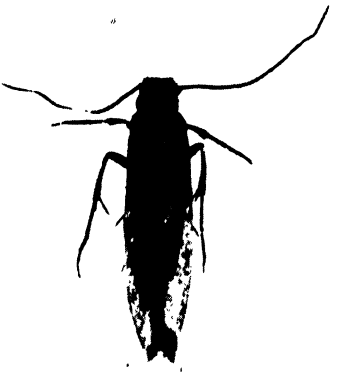
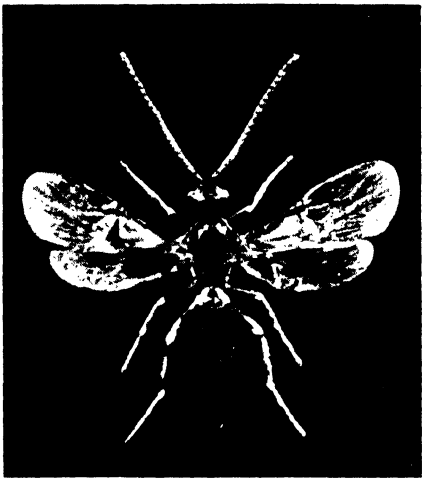
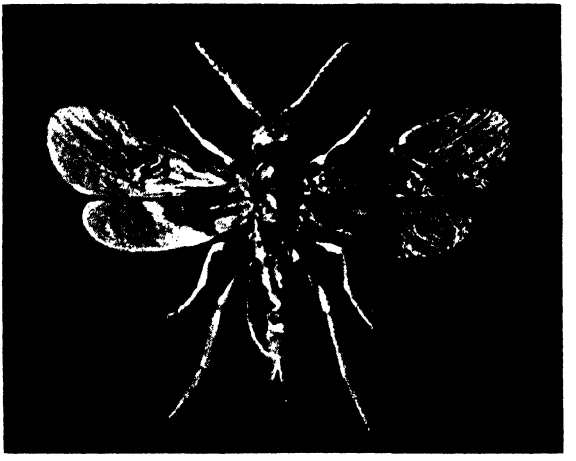


FIG. 109.—*Tineola biselliella Hummel.* × 6.

FIG. 110.—*Trichophaga tapetiella. L* × 4.





Microbracon (Habrobracon) hebetor Say.
FIG. 111, at top, male. × 10;
FIG. 112, below, female, × 10.

To face page 37.]

fore-wings light greyish yellow with three more or less conspicuous dark spots ; hind-wings light bronzy-grey ; 10–14 mm. long. The larvæ are in a silken case amongst its food, which is usually woollen cloth, carpets, hair, fur, feathers, stored tobacco, felt, piano keys, aconitum root, cayenne pepper, horse-radish, cherry laurel leaf, black mustard seed, ginger, orris root, linseed, almonds, saffron.

Tinea flavescentella is a local moth in Britain and South Europe. Head pale greyish-yellow. Fore-wings pale glossy greyish-yellow ; a short-cloudy ill-defined dark fuscous suffusion from base near costa with other ill-defined fuscous markings on upper surface. Hind-wings whitish-grey. It is 11–16 mm. long.

The larva is whitish with brown head and brown plates on second segment.

Larva in case is found amongst wool and fur. A destructive pest when in numbers.

Tineola biselliella is called the common clothes moth, and is cosmopolitan. Head pale yellowish ; fore-wings uniformly golden-buff, unspotted ; hind-wings yellowish-grey ; 9–16 mm. long. The larvæ are whitish, with brown head. Found on wool, ware-house walls and windows, houses, stored wheat and corn ; larvæ on wool, hair, clothing, carpets, feathers, dried skins.

Trichophagus tapetiella is also cosmopolitan, and is called the tapestry moth. Head white ; fore-wings with basal half black and apical half white, sometimes tinged with blackish scales ; 15–22 mm. long. The larva is yellowish-white with brown head, and lives in silken galleries amongst its food. Recorded on

wool, rags, warehouse walls and windows, houses; larvæ on wool, rags, hair, clothing, carpets, feathers, dried skins.

HYMENOPTERA

Braconidæ

THE *Braconidæ* are a group of parasitic insects closely allied to the *Ichneumon* flies. They appear to attack the larvæ of lepidoptera, and it has been recorded that more than one hundred specimens of an individual species of braconid may issue from a single caterpillar. The larvæ usually gnaw their way out of the body of the host and pupate externally, but in certain species pupation takes place within the host.

Microbracon (*Habrobracon*) *hebetor* is cosmopolitan. It is a small insect with fairly long ovipositor, with which it punctures the small caterpillars of *Ephestia* and *Plodia*. Colour is from yellow to black; very variable is size; 3–5 mm. long. The larvæ are small, white; from 2 to 14 in each caterpillar—where the large number occurs the resultant adults are very small. Found on sultanas, cacao, currants, figs, dried pears and Canadian flour infested by *Ephestia kuehniella*. The larva is a parasite of those of *Plodia* and *Ephestia*. It appears to attack exclusively the larvæ of moths living in stored products. The adult insects are mainly found in the late summer.

DIPTERA

Scenopinidæ

Scenopinus fenestralis has been known as the carpet fly, because it was often found on old carpets and rugs. Its larvæ do not feed on the wool or hair, but upon the larvæ of other insects, such as *Tinea* and other lepidoptera. It is found in Europe, North America, India and North Africa, and is a smallish black fly with red legs; it is 5–6 mm. long. It has been recorded on wheat, windows of warehouses, stables and outbuildings. The larvæ feed on those of other insects.

Scenopinus niger is very similar to *fenestralis*, but its legs are black; it is 5–6 mm. long. Same distribution as, and under similar conditions to, *Scenopinus fenestralis*.

HEMIPTERA

THE next family to be dealt with is the Anthocoridæ, of the order Hemiptera. Among these, *Lyctocoris campestris* is predaceous on mites and various larvæ, and is one of the commonest of British bugs. It is cosmopolitan, pale yellowish-brown in colour, very flat, with long piercing proboscis, and is 3½ mm. long. The larva is similar to adult in all its stages, and equally predaceous on small larvæ, eggs and pupæ of *Ephestia* and *Plodia*, as well as on any other species of larvæ and mites of all kinds. Recorded in warehouses, crushed oats, wheat, flaked maize, cattle food, barley, feeding nuts, grass nuts.

ORTHOPTERA

Blattidæ

Blatta orientalis is the common or oriental cockroach. It is not a British species, but has now become naturalized, and propagates under favourable but unnatural conditions. It has been distributed throughout the world in commerce, and is an omnivorous pest and spoils much more material than it consumes. It is brown to blackish-brown in colour, depending on age, and is about 25 mm. long when fully developed. In the female the wings are much smaller than those of the male, but in both sexes they are too small to permit flight. It prefers starchy and sweetened material, but is known to attack other insects. It has been found in houses, bakeries, restaurants, hotels and shops. The eggs are laid in a pouch which is deposited in a crevice, always where the temperature ranges from 75 to 90° F., for the eggs to hatch. The eggs are not deposited where temperature is low. The dark brown oötheca is about 12 mm. long by 6 mm. broad, containing two rows of eight eggs, *i.e.*, sixteen eggs in each pouch. The eggs are generally deposited near a food supply.

Blattella germaniea is the German cockroach or steam fly. This is also a domesticated species having been introduced in commerce, but it is not so prevalent as the common cockroach, except under specially favourable conditions in centrally heated buildings, hotels, cafés, hospitals and bakeries, where it swarms in incredible numbers. The oötheca is dark brown in

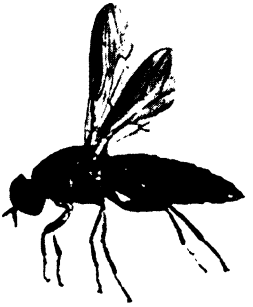


FIG. 113. *Scenopinus fenestralis L.* × 5.

FIG. 114.—*Scenopinus niger De G.* × 5.

[*To face page* 40.

FIG. 115.—*Blattella germanica L.* × 2.

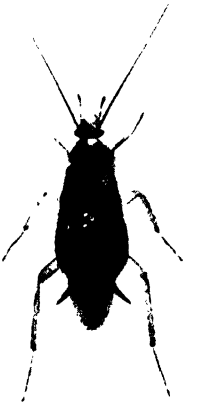


FIG. 116, below, *Lepisma saccharina L.* × 6.

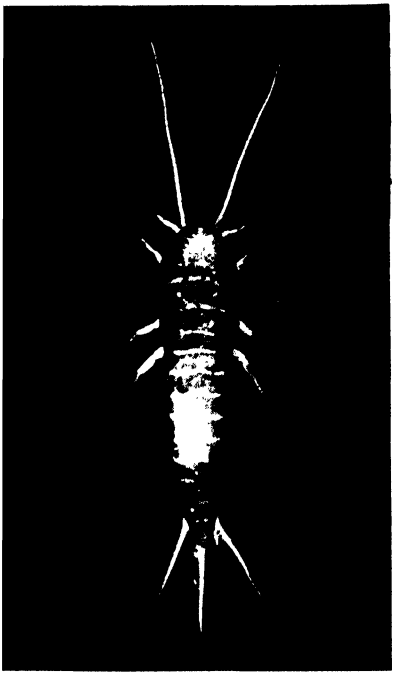
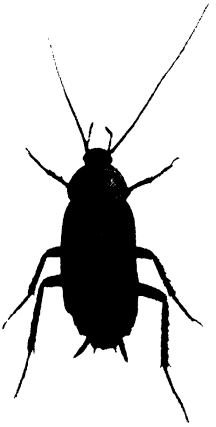
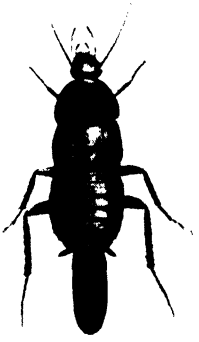


FIG. 117.—*Lyctocoris campestris F.* × 6.





Blatta orientalis L. FIG. 118, above, male, natural size ; FIG. 119, below, female with Oötheca, natural size.

FIG. 120.—*Periplaneta americana L.*, natural size.

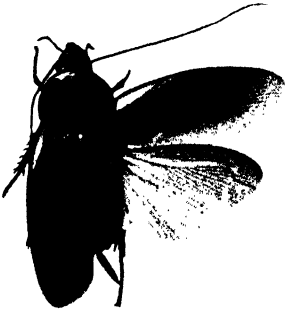


FIG. 121.—*Periplaneta australasiæ F.*, natural size.

colour, about 7 mm. long and 3 mm. in breadth, and contains from 18 to 20 eggs on each side. It is recorded that forty young were produced from a single oötheca. Both sexes of this cockroach are fully winged.

Periplaneta americana is called the American cockroach, and was first described in 1758. It is widely distributed. The mature insect is large, bright, sienna brown, fully winged in both sexes ; antennæ are much longer than the body. It is 35 mm. long ; oötheca dark brown, containing 14 to 16 eggs. It is the largest cockroach breeding in the British Isles, and occurs in houses, breweries, bakehouses, warehouses, docks, sugar refineries, rubber and dye works, nurseries, and hothouses.

Periplaneta australasiæ is the Australian cockroach ; it was first described in 1775, and is cosmopolitan. This species is slightly smaller than *Americana*, rich sienna brown in colour, fully winged in both sexes, elytra with a yellow streak, and pronotum with a yellow border all round. It is 27 mm. long. Apparently no oötheca has been described. Destructive in glasshouses to various plants, especially ripening bananas and orchids.

Leucophæa surinamensis is the Surinam cockroach, described in 1758, and is cosmopolitan. It is black, with pale yellowish front margin to pronotum ; elytra yellow-brown with pale streaks ; fully winged in both sexes ; 20 mm. long. Oötheca is 8 mm. long, 2·8 mm. high, and 1·8 mm. broad. It breeds in tan-pits and hothouses, doing considerable damage to growing pineapples, orchids and bananas.

About twenty other species of cockroach have been recorded from docks and warehouses, having been introduced amongst fruit and other commodities, but so far they have not been able to establish themselves in our climate.

THYSANURA

Lepismidæ

Lepisma saccharina is known as the silver fish insect, and is found in Europe and North America. It is clothed with scales, and, as its name implies, is silvery in colour. It is wingless, moves rapidly, and frequents dark places ; in older houses it frequents the fireside, hiding in the crevices and under the hearthrug. Found on wheat, bran, thirds, warehouse walls and floors, bundles of papers, stored books, sugar stores, between crevices of boards ; is often a serious pest in bakeries.

Thermobia domestica is called the fire brat, and is widely distributed. It is very similar to the silver fish, but is clothed with black and yellow scales, which give it a much darker appearance. Found in bake-houses and kitchens, always about the hottest spot ; has similar habits to the silver fish. It has been stated to live among red-hot cinders—hence the name " fire brat."

SIPHONAPTERA

Pulicidæ

THE siphonaptera or fleas have been included because during many years of work on the identification of insects and other pests in warehouses, stores, etc., these pests and their larvæ have frequently been captured by various workers.

About 1000 species of flea are known, and of these 46 are known to occur in the British Isles. Only a few of these are found in stores and warehouses.

Fleas are parasitic on mammals and birds, and those dealt with in this survey are those associated with man and certain mammals, which are working in storage centres either as depredators or as helpers in checking depredations.

The life history of all fleas are very similar ; the female deposits her eggs either in the nest or on the host, and in the case of animals amongst the fur. As the animal moves about, the eggs may be spread upon stored products.

The larva which hatches from the egg does not feed on the animals, but on the scaly detritis which falls from the bodies of the animals, together with the undigested blood voided by the fleas, and the fragments of hair and other rubbish in the nests. When the larvæ are fully grown they spin a small silken cocoon intermixed with particles of material amongst which they are living. They emerge as the mature insect in about 14 days or longer, depending on the temperature at the time.

Xenopsylla cheopis is found principally in dockside

warehouses, and is derived from the black and brown rat. This insect is the principal carrier of Bubonic plague, so that it is a very dangerous and unwelcome visitor. It is a small pale yellowish-brown species, 2–2½ mm. long, and is cosmopolitan in distribution. It has been recorded in rats' nests and on wool.

Pulex irritans is the flea principally associated with man. It is a much larger dark brown species, 3–3½ mm. long, and is a stout heavier built insect. It is less common than formerly. At one time it was abundant in cinemas, theatres, public buildings and public conveyances, but the advent of the vacuum cleaner has practically exterminated it in these places. It is still found in warehouses and stores, particularly where dogs and cats have been installed to check the depredation of rats and mice. It has been found on the following stored products :—Rags, wool, hemp shoes.

Ctenocephalides canis, the Dog flea is not abundant. It is associated with both the dog and cat, and is cosmopolitan in distribution. It is pale brown in colour and 2½–3 mm. long. It has been recorded on wool and flour.

Ctenocephalides felis is known as the Cat flea, and it is cosmopolitan in distribution. It is common on the dog and is known to attack many other animals. It is pale brown in colour and 2–2½ mm. long. It has been recorded on flour and wool, and the larvæ on cardboard boxes.

Nosopsyllus fasciatus is generally known as the Rat Flea, though it is also found on the house mouse. It is 2½–3 mm. long and is a more slender species. It has

FIG. 122. *Xenopsylla cheopis Roths.*, male. × 12.

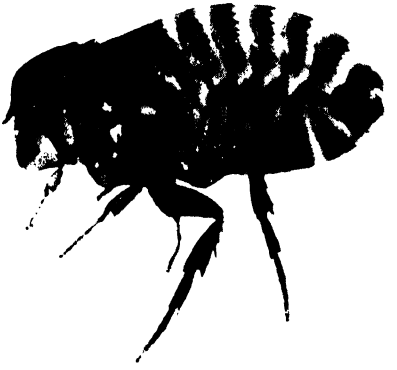


FIG. 123. *Xenopsylla cheopis Roths.*, female. × 12.

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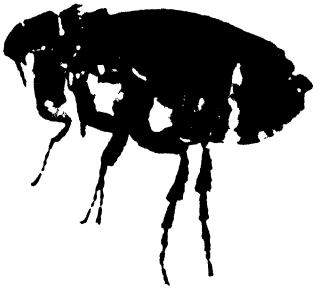


FIG. 124.—*Ctenocephalides canis Curt.*, male. × 12.

FIG. 125.—*Ctenocephalides canis Curt.*, female. × 12.

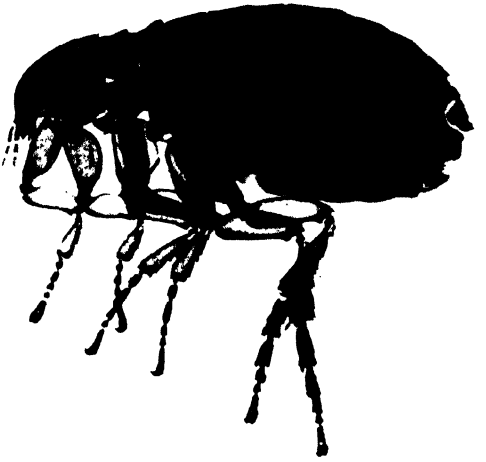


FIG. 126.—*Pulex irritans L.*, female. × 12.

FIG. 127.—*Ctenocephalides felis Bouche*, female. × 12.

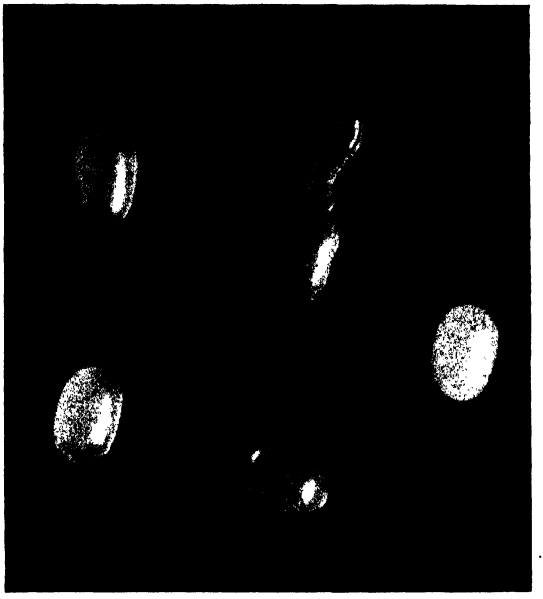


FIG. 128.—*Ctenocephalides felis Bouche*, ova, one just hatch[ed] × 25.

Ctenocephalides felis Bouche.

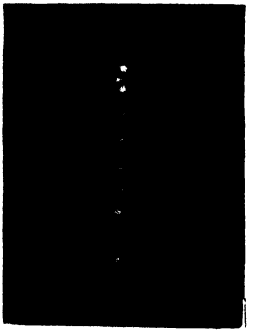


FIG. 129. Larva. × 11.

FIG. 130. Pupa. × 12.

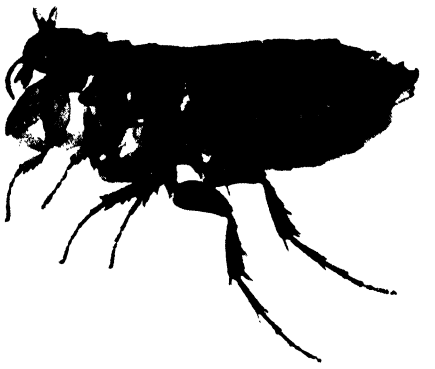


FIG. 131.—*Nosopsyllus fasciatus Bose*, male. × 12.

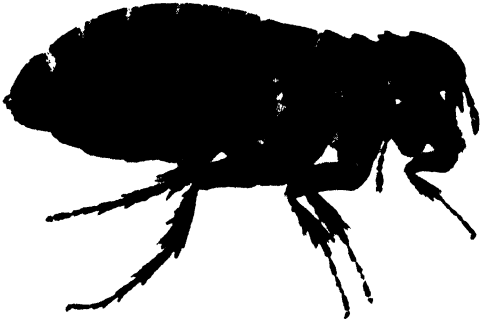


FIG. 132.—*Nosopsyllus fasciatus Bose*, female. × 12.

FIG. 133.—*Leptopsylla segnis Schon.*, male. × 12.

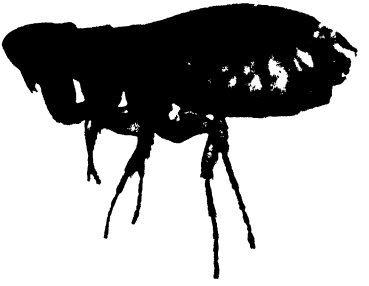


FIG. 134.—*Leptopsylla segnis Schon.*, female. × 12.

To face page 45.

been frequently found in warehouses, especially in the vicinity of the nests of rats and mice. It has been recorded on corn, flour, bran, carpets and in granaries, and the larvæ on carpets. It is widely distributed throughout the British Isles, and is cosmopolitan. It is reputed to be a carrier of the bacilli of Bubonic plague.

Leptopsylla segnis, the mouse Flea is abundant on the house mouse and, as might be expected, is frequently found in stores, warehouses and other premises frequented by this mammal. It is a very slender species, light brown in colour, and 2–2½ mm. long. It has been recorded on flour, wool, rags and grain.

This is the only species dealt with which is not known to attack man, so is much less of a menace than the other fleas described.

Many of the complaints regarding fleas can be attributed to unclean domestic animals, rats and mice.

PSOCOPTERA

Psocidæ

THE insects in this group are small or of minute size with soft bodies. They have been called book lice and dust lice because they are frequently found in old collections of papers and books. They feed upon the paste in book bindings, and upon mould growths which develop in paper. At times they resort to flour, meal and other cereal products, straw and chaff. They also frequent damp walls, no doubt feeding on the moulds and fungi.

Clothilla (*Atropos*) *pulsatoria* is commonly called the book louse. It is cosmopolitan, white in colour, and about 2 mm. long, femora of hind legs not swollen. Found on windows, walls and floors of warehouses, wheat, barley meal, imported Japanese baskets, paper, sweepings, houses, dried fruit, old books and papers, and in natural history collections, to which it is extremely injurious.

Lepinotus inquilinus is European. It is about 2 mm. long and dark brown in colour; femora of hind-legs swollen. It is found on flour, sweepings, walls and floors of warehouses. A domestic species.

Troctes (*Liposcelis*) *divinitoria* is known as the book louse. It is cosmopolitan, about 1·75 mm. long, and pale brown in colour, with strongly swollen femora to hind legs. Found on hops, warehouse walls, sweepings, dried fruit, in houses and warehouses, and on old papers and books.

The term "death watch" has been applied to certain species of *Psocidæ*, because they possess the power of producing a ticking noise. This should not be confused with the "death watch beetle"—*Xestobium rufovillosum*—which also is capable of sound production. In the *Psocidæ*, sound production has only been proved of *Clothilla pulsotoria* and *Lepinotus inquilinus*. The sound produced is regarded as a mating call.

ARACHNIDA

THE survey of the more important insects which are found on stored products has now been completed, but

the list does not include all insects which have been found. Certain insects show preferences for relatively few products, and are rarely if ever found on other products. These have not been included in the list, as they are not considered of sufficient general importance.

Stored products at times are infested by creatures which are not insects, but which are sometimes mistakenly called insects, because of their habits and appearance. Amongst this class are the mites and false scorpions, which are members of the Arachnida.

Tyroglyphidæ

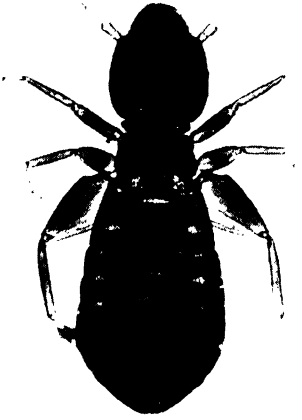
In this group are found the flour or meal mite and the cheese mite, and they are the two most commonly found on stored products. The " dust " which collects around sacks of bran, flour, and ground cereal products consists mainly of " mites," together with flour or meal in a finely divided state. When the " dust " is examined through a lens, it will be noted that there are thousands of small moving objects. The individual mites are too small to be seen by the naked eye. An easy method of determining if live mites are present to any extent is to scrape some of the dust together in a heap about an inch high, and square the edges with a piece of wood, cardboard or a postcard. If mites are active, the dust will begin to move, and in less than five minutes the square sides will have disappeared, due to the movement of the mites. If the heap is left for a longer period it will be almost flat after about fifteen minutes.

Mites differ from insects in several respects. They have four pairs of legs and no antennæ.

Tyroglyphus farinæ is known as the flour or meal mite. It is cosmopolitan, and the one most common in stored products. It is almost white, with ruddy brown mouth parts and legs and about 0·40–0·70 mm. long. The male can be recognized by having a strong tooth-like projection on the thickened front pair of legs. The life cycle is egg, larva, nymph and adult. The larvæ and nymphs are similar to the adult, except in size and in having paler legs, with absence of sexual differences. When attacking grain, the mite bores into the soft plumule, usually eating this fi and gradually attacking the whole of the grain until nothing but the husk is left.

It has been found on middlings, bran, thirds, cockle wheat, screenings, flaked maize, flat corn meal, rolled horse corn, biscuit meal, cattle feeding nuts, mill siftings, sweepings, rolled oats, bran meal, laying meal, seconds, ground linseed cake, ground oats, flour, maize meal, feeding meal, broad bran, cattle cake, meal, horse corn, cattle feeding meal, chick mixture, oats, linseed meal, wheat meal, cotton seed meal, cattle-feeding nuggets, fine offal, B. & W. oats, sharps, wheat, oatmeal, linseed cake, cakelettes, dairy nuts, layer's mash, stamina, rice meal, straw, calf nuts, dairy meal, fattening nuts, chick growing food, chick baby food, old sacking, fattening all-mash, balanced ration, Sussex ground oats, barley meal, chick scratch feed, shudes, layer's pellets, chick meal, baby beef, layer's scratch feed, grower's mash, chick mash, pig meal, layer's all-mash, ground scratch feed, maize

FIG. 135.—*Troctes divinitoria Mull.* × 20.



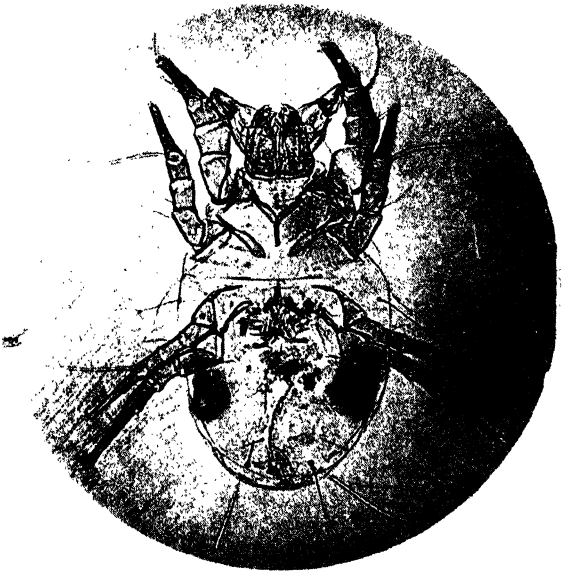


FIG. 136.—*Tyroglyphus farinæ L.* × 75.

[*To face page* 48.

PLATE 52

Tyrophagus dimidiatus Herm. FIG. 137, right, adults. × 16; FIG. 138, below, cast skins in sweepings. × 75.

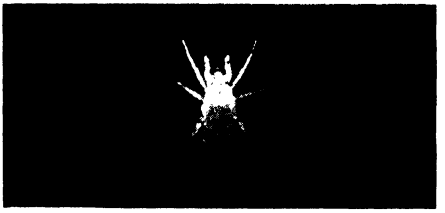


FIG. 139.—*Cheyletus eruditus Schr.* × 6.

FIG. 140.—*Chelifer museorum Leach.* × 6.

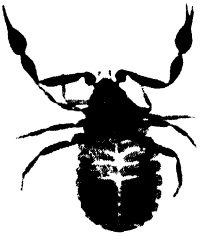
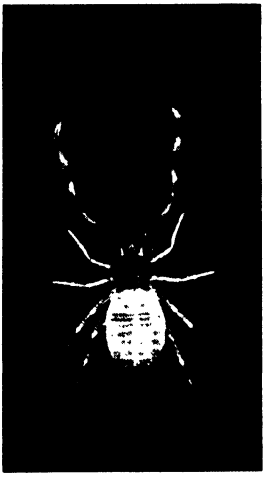
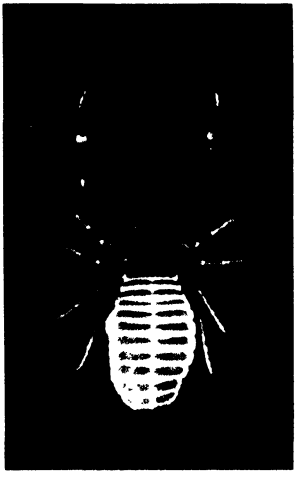


FIG. 141.—*Chelifer cancroides L.* × 6.

PLATE 54





Chernes panzeri C. L. Koch. FIG. 142, above, male. × 6; FIG. 143, below, female. × 6.

To face page 49]

cubes, soya meal, calf meal, pinhead oatmeal, sheep and lamb nuts, poultry biscuit and meat meal, fattening meal, nutted cotton cake, calf feeding nuts, bean meal, feeding cake, horse feed, sheep nuts, growing food, Rangoon rice, linseed cake meal, layer's all-mash pellets, grower's nuts, commercial mash, nutted linseed cake, grass nuggets, grass meal, calf meal, dairy nuggets, balanced ration nuggets, super milk meal, growing meal, pig rearing meal, super milk nuggets, cakelettes, chick growing meal, laying winter meal, lamb nuts, calf nuts, poultry nuts, pig nuts, ewe and lamb nuts, pig fattening meal, wheatings, high carbohydrate cakelettes, screened linseed, chick feed meal, rye flour, growing mash, cotton cake nuts, poultry fattening meal, dairy milk meal, pig food, Scotch feeding meal, chick scratch, feeding nuts, linseed bean meal, feeding cakelettes, record dairy cakelettes, sheep and lamb cakelettes, chick raising meal, ration meal, fattening oats, rearing nuts, cake nuts, milk nuts, balanced dairy meal, ground nut flakes, milk meal, grass nuts, dairy cake nuts, round plate linseed, poultry raising meal, lamb food, farina, horse food, hop grass nuts, calf nuggets, A.S. nuggets, high yield meal, weaner's pellets, turkey food, poultry corn, and on warehouse floors. It is often more abundant on cheese than is the so-called cheese mite.

Tyrophagus dimidiatus is known as the cheese mite. It is cosmopolitan, but not so widespread as *Tyroglyphus farinæ*. It is yellowish-white in colour, and about 0·45–0·70 mm. long. It is similar in appearance to *Tyroglyphus farinæ*, but is polished without markings, and with long hairs on the body. The life cycle is

egg, larva, nymph and adult. The larva and nymph closely resemble the adult female except in size, becoming gradually larger with each moult. Recorded on cheese, flour, meal, cattle-feeding cake, and probably feeds on most organic materials.

Thrombidiidæ

Cheyletus eruditus is a European species. It is yellowish-brown in colour and about 0·70–0·90 mm. long. It has a polished appearance, with long legs and very strong palpi armed with comblike grasping organs at the end, with which it grasps the mites on which it feeds. The life cycle is egg, larva, nymph and adult. All stages are similar to adults except in size and lack of visible reproducible organs. This species is predaceous on *Tyroglyphidæ*, and infested consignments have been found where this has been the only " mite " present. It is probable that the consignments were originally infested by *Tyroglyphidæ*, and that they were subsequently exterminated. Recorded on bran, chick scratch feed, chick all-mash and feeding meals.

FALSE SCORPIONS

Cheliferidæ

THE members of this family are predaceous on mites and small insects, and they are therefore beneficial. The presence of members of this family generally indicates infestation by some insect or by mites.

Chelifer cancroides is cosmopolitan. It is about 3·2 mm. long and reddish brown in colour. It has a

long parallel sided body, with four pairs of long legs, and very long stout palpi which have a broad hand-like extremity armed with a fixed and a movable finger-like organ, used for seizing their prey. The life cycle is similar to that of the mites—egg, larva, and nymph, which in all stages are replicas of the adults except as regards size. Found on oats, and in bakeries, stores and stables. Predaceous on insects and mites. Frequently found associating with *Tyroglyphidæ*.

Chelifer museorum is a European species. It is about 1·1 mm. long and rich reddish-brown in colour. It is strongly flattened and ovate in shape, the head at the narrow end, four pairs of fairly long legs, and palpi longer and stronger, with stout hand and fairly long fingers. The life cycle is similar to that of *Chelifer cancroides*. Recorded in meal, flour mills, hay lofts, warehouses, and sweepings. Frequently found associated with *Tyroglyphidæ*.

Chernes panzeri is a European species. It is 2·6 mm. long, of a dull red brown colour, shading to horny brown on the abdomen, and is sparsely covered with clavate and toothed bristles. It is the most abundant of all the chelifers in the British Isles, and is found in stables, cow-sheds, barns, warehouses and flour mills. It feeds on various mites, such as *Tyroglyphidæ*, and also small insects, especially *Psocidæ*, and is therefore a useful animal in the stores. The life cycle is similar to that of *Chelifer cancroides*.

CONTROL MEASURES

HAVING considered the insects, etc., which infest stored products, we should now consider methods of control.

One of the most important methods and incidentally one of the easiest for the warehouseman, is warehouse hygiene. Cleaning of warehouses and stores is too frequently neglected, with the result that infestation passes from consignment to consignment until the whole of the stock is infested in varying degrees. If the following points are observed in warehouses and stores, the probability of infestation will be reduced.

A space at least 2 feet wide should be allowed between different consignments. Sacks, bales, etc., should not be stored against the walls; a space of 2 feet wide should be allowed. These precautions will enable regular inspections to be made for insect pests.

Regular sweeping of the floor is essential, and when a consignment has been removed the floor should be brushed before new stock is stored on the vacant space. Grain, meal, etc., is often spilled from bags during trucking, and it is important that this overflow be removed immediately trucking is completed; otherwise the material finds its way into the crevices between the floorboards, and provides food for insects. Sweepings from floors should not be allowed to accumulate in bins or sacks in warehouses; they should be removed from the warehouse and burned.

There should be ample ventilation in warehouses

and stores. Artificial heating is undesirable except for certain selected commodities. There is much less danger of damage from insect pests if the temperature of the store is kept low.

New stocks should be examined on arrival for the presence of pests, and at monthly intervals afterwards. The most likely places are between adjacent sacks, in the folds and seams, at the tops of the sacks, and amongst the grain, etc., in the sacks. Where the infestation is due to moths, or partly to moths, the latter may be found in the places outlined above, and on adjacent windows.

If punctured grains are found in the course of examination, the particular stock should be carefully watched, because it will indicate that pests have been present in the grain, and the holes may contain eggs of weevils which will subsequently hatch out.

Empty sacks are a source of infestation to warehouses and commodities. If they have to be warehoused, it is important that they be stored as far apart from foodstuffs as is practicable. The best course is to store in an isolated shed.

Where grain is stored in bulk, more frequent examinations are necessary than when it is stored in sacks, and regular examinations should be made at the fringe of the pile and at the peak. The temperature should be taken daily by means of a thermometer mounted on a spear-head, and the readings recorded. When the temperature exceeds 63° F., more frequent examinations are necessary, because the risk of infestation is greater.

One practice which is sometimes adopted is to

attempt to cool down the pile by turning it over and mixing. This is not recommended. If the pile is infested, the most probable result will be to disturb the pests and cause their migration to other stocks in the building. The most satisfactory procedure is to remove the whole of the grain from the building in sacks. It could then be processed as originally intended, or, if this is not convenient it could be stored in an isolated shed.

The most satisfactory course to adopt when infestation is found is to remove the affected consignment from the main store.

The screening of grain will remove most of the insects present, but it will not eliminate the eggs or larvæ which may be within the individual grains. It is therefore necessary to screen at intervals of about three months during the summer period to deal with those insects which have matured.

Where a warehouse or store has become seriously infested, some means must be employed to reduce the insect population, but in many instances skilled operators are necessary to apply the particular method. Many methods have been suggested, but some of them have not progressed beyond the laboratory stage, or are prohibitive in cost. Fumigation by gases and by liquids which evolve toxic vapours has been applied in many warehouses, but it should only be performed by skilled operators. A development of recent date, particularly against moths and their larvæ, is the use of sprays, where substances dissolved in oil are atomized. This method is applied in the protection of cocoa, tobacco and dried fruit.

The use of certain mineral substances in the form of a dust has been suggested for the protection of grain. This method has been applied on the Continent; its advantages are that unskilled labour can be used for mixing, and that the normal cleaning processes can be used for the removal of the dust. Further experience may result in its extended use.

Certain physical measures, such as the use of heat, cold, dryness, infra-red rays, and high-frequency electrical waves, etc., have been suggested, but they are not in general use.

The migration of crawling insects can be considerably reduced by the use of certain proprietary substances. The usual method is to place a track about 4 to 6 in. wide round an infested consignment. Some of these substances are "tacky," and when the insects come into contact with the track they are trapped. In dusty situations this method is not effective unless the track is regularly renewed and kept in a tacky condition. Cases have been known where a track of from 1 to 2 in. wide has proved ineffective with a seriously infested stock, because so many insects were trapped that the others walked over their backs. Another method relies upon the odour of carbolic acid to keep the insects from migrating. The carbolic acid is incorporated in a soap jelly, and a solution is made and applied to the floor. A track about 6 in. wide is necessary, and it should be renewed daily. When this method is applied for the protection of flour, the track should be at least 4 ft. distant from the bags to prevent contamination by odour.

When a consignment has been seriously infested by

mites, the floor area should be treated before new stock is stored ; otherwise the new stock will become infested. Although the floor may have been well brushed after removal of the old stock, there may be millions of mites in the crevices between the floorboards. After a few days the mites will work up from the crevices, and the floorboards will be covered with a light brown dust which will consist mainly of mites. An effective method of treatment is the following :

Dissolve soda crystals in water in the proportion of 1 lb. to one gallon, and apply to the floorboards, taking care to saturate the debris in the crevices between the floorboards. Repeat after three days, and then allow to dry. The space should be ready for use after 14 days. If the space treated is on an upper floor, the goods on the floor beneath should be protected by tarpaulin sheets when the solution is applied. The treatment with soda is also effective in dealing with larvæ of Lepidoptera in the crevices between floorboards.

In many warehouses, insect pests propagate in the space between the warehouse walls and floors, because there is generally an ample food supply. In addition, insects can migrate to the floor below via this crevice. A method which has proved effective is to place a triangular wood fillet at the junction of walls and floor. The fillet should be set in mastic cement and nailed to the floor ; if it is properly set, insects will not be able to pass under or behind it. The mastic cement is used to compensate for irregularities in the floors and walls, and in use it has been found to withstand vibration due to trucking, etc.

As the crevices between the floorboards provide a propagating space for insect pests, it is desirable that the crevices be cleaned from time to time. A satisfactory method is to scrape the crevices to loosen the debris, and follow with a vacuum cleaner provided with powerful suction. The use of suction without the preliminary scraping is useless. When the crevices are clean, they can be filled with wood strips (if very wide), mastic cement, or lime paste. The latter is prepared by slaking quicklime with a small quantity of water. Experience has shown that the best results are obtained if the paste is applied while still hot. The paste can be applied and forced into the crevice with a trowel, but a rubber squeegee is more satisfactory and quicker for large areas.

List of

SUBSTANCES AND THEIR PESTS

In this list the left column gives the name of the substance or place likely to be infested, whilst in the right will be found the pests that have been found infesting it. Reference to the individual pests is achieved by the index at the back of the book.

LIST OF PARASITIC AND PREDACEOUS INSECTS AND THEIR HOSTS

Pests parasitic upon others will be found to the right of their hosts.

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